Lithic Technology at The Below Forks Site, FhNg-25:

Strategems of Stone Tool Manufacture.

A Thesis Submitted to the College of
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In Partial Fulfillment of the Requirements
For the Degree of Master of Arts in the
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By
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ABSTRACT

The Below Forks site is a deeply stratified multicomponent archaeological site situated two kilometres downstream from the confluence of the North and South Saskatchewan Rivers. The lowest cultural occupation has been dated to 6000 rcybp. Projectile points diagnostic of the Mummy Cave series were recovered from excavations. The site was an open campsite situated on a middle level alluvial slope of the Saskatchewan River valley. A broad-spectrum fauna exploitation was represented at the site. The lowest component was occupied in late winter or early spring, based on immature bison elements. Collection and reduction of river cobbles into lithic implements was an important activity at the site. Debitage was the largest artifact class recovered from the site and deserved the greatest analytical attention.

Lithic technology, specificially the methods of tool manufacture, was the central theme of study. A variety of analytical techniques were used, including the separate analyses of cores, debitage, and tools. These analyses were placed into a spatical context with geographic information systems. Three components were represented in the eastern area of the Below Forks site. A lithic reduction workshop and some habitation debris were contained in the upper occupation. Evidently, the middle component appeared peripheral to a habitation site. The lower occupation evidenced significant knapping activities within the confines of a habitation site.

Interpretations from various analytical techniques were placed within a *chaîne opératiore* framework and fully documented the lithic technology. Certain types of material behaved in slightly different ways; individual knappers would have taken this into account and appropriately modified their technique. The thermal alteration of Swan River chert was an important component of the lithic technology. Bipolar technology had a prominent role in the production of flake blanks. Platform grinding was a commonly observed form of platform preparation. Platform flaking increased in importance with later stages of reduction. Ideally these preparations would allow flint-knappers to improve their control of intended flake detachments. In sum, lithic tools were manufactured

within a myriad of technological sophistication. The properties of lithic fracture were controlled with great precision, preparation, and foresight in the manufacture of implements at the Below Forks site.

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LIST OF ABBREVIATIONS

Decort	Decortication
Dst	Distal flake portion
Es-n	Early Side-notched
FCR	Fire Cracked Rock
FI	Flake Initiations
G!	Grade one of Ahler's (1986) size grade analysis
G2	Grade two of Ahler's (1986) size grade analysis
G3	Grade three of Ahler's (1986) size grade analysis
G4	Grade four of Ahler's (1986) size grade analysis
GIS	Geographical Information System
KRF	Knife River flint
Lb	Left Break
Ls	Left Split
Med	Medial flake portion
MCs	Mummy Cave series
NAS	Number of Artifactual Specimens
Prx	Proximal flake portion
Qite	Quartzite
Qtz	Quartz
Rb	Right Break
RRC	Red River chert
Rs	Right Split
Sil. Peat	Silicified Peat
Sil. Wood	Silicified Wood
SRC	Swan River chert
SRT	Sullivan and Rosen Technique

"the enchantment of technology is
the power that technical processes have
of casting a spell over us so that we see
the real world in an enchanted form"
Arthur Gell (1992:44).

1. INTRODUCTION.

1.1 Thesis Problem.

The goal of this thesis is to address questions regarding the nature of stone tool manufacture characteristic of the Early Side-notched/Mummy Cave series on the Northern Plains using evidence from the Below Forks site. Figure 1.1 illustrates the location of the Below Forks site in relation to other important archaeological sites named in the text. In reviewing the literature on Early Side-notched sites (eg. Doll 1982, Frison 1991; Gryba 1976; Quigg 1984; Reeves 1978; Shay 1971; Walker 1992; Zurburg 1991), it is apparent that the process of lithic manufacture has not been addressed in detail. Most site reports contain excellent descriptions of stone tool assemblages, but downplay how the tools were made. Few debitage analyses are included in these papers and site reports. In order to fully interpret the manufacture process of lithic tools a detailed debitage analysis was seen as necessary.

Material from the eastern area of the Below Forks site was analyzed with regard to lithic technology and tool manufacture. The paucity of tools at the site forced a detailed debitage analysis that addressed specific aspects of manufacture technology in an aim to analyze beyond the finished products. The nature of flake blank production was further interpreted from an analysis of cores. In turn, tools were analyzed with techniques of their manufacture in mind. Interpretations of lithic technology from debitage, tools and cores were combined into a spatial framework. The context of reduction was established in this manner. Tool form and function are well known for the Early Side-notched period, but tool manufacture is poorly understood; such a data gap was both a problem and a benefit for the thesis.

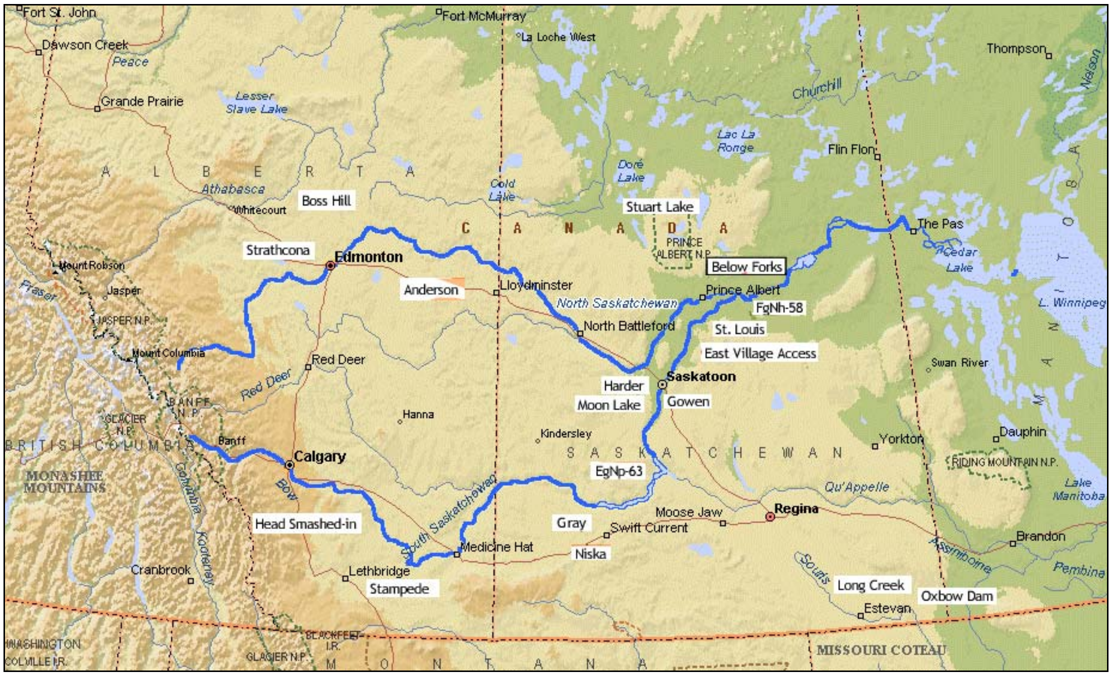


Figure 1.1. The location of the Below Forks site and important archaeological sites of the Canadian Plains.

1.2 Research Questions.

Ten questions have guided the study of lithic technology at Below Forks. These are:

1. What were the types of lithic raw material present in the site?

2. What was the ratio of local, regional and exotic materials at the site?

3. What type of preparations were done on the raw material?

4. What was the nature of thermal alteration in the lithic assemblage?

5. At what stage did thermal alteration occur?

6. What were the relative stages of tool manufacture?

7. At what stages were hard hammer, soft hammer and pressure detachment techniques applied?

8. What was the type of core reduction technology?

9. What was the type and distribution of platform preparation in the stages of manufacture?

10. What was the tool assemblage? Were there distinguishable techniques in the manufacture of individual tool types?

An interconnected interpretation of the lithic technology of Below Forks will become apparent as these questions are answered.

1.3 Introduction to Archaeological Research in the Study Region.

Thomas Kehoe and David Meyer have conducted research in the vicinity of the Forks. Kehoe was the first archaeologist to visit the Saskatchewan Forks area. This occurred in the summer of 1960. From conference proceedings it is known that:

> Kehoe reported activities of the Saskatchewan Museum in the Northern part of the province, including his three hundred mile trip by boat on the Saskatchewan River between Prince Albert and Cumberland House (Western Canadian Archaeological Council, 1960:7).

He voyaged down the Saskatchewan, passing the confluence, in 1960 to assess the Tobin Lake development by Saskatchewan Power Corporation (Kehoe 1978:7).

David Meyer investigated the area of the confluence in 1980 as part of the Saskatchewan Forks survey (Wilson 1982:839-842). Sponsored by the Saskatchewan Power Corporation, the Saskatchewan Forks survey was an intensive archaeological reconnaissance project related to a proposed hydroelectric dam at Horseshoe Bend (Wilson 1982:743). This dam would have been located six kilometres downstream from the confluence. Two basic survey strategies of areas that would be inundated after dam construction were employed: field walking of areas under cultivation and investigation of exposed river cut banks (Wilson 1982:788-792). Since the Forks survey, very little consulting archaeology has been conducted in the river valley near the confluence, mainly due to a lack of monitored development. In recent years, Douglas Frey (1996,1997) has been recording and collecting from archaeological sites in the Prince Albert region.

1. 4 Discovery and Chronology of Excavation of the Below Forks Site.

The Below Forks site was discovered by David Meyer and William Ferris while investigating a cut-bank with exposed deep stratigraphy downstream of the confluence of the North and South Saskatchewan rivers (Figure 1.2) (Wilson 1982:839). The site is situated on the upstream edge of a relic point bar and is exposed by rotational slumping. In this situation, significant quantities of faunal and lithic archaeological material were observable 2.5 metres below surface (Wilson 1982:839). A one by two metre test unit at the western most portion of the site was excavated by Meyer, Ferris and Olga Klimko (Meyer 1990:1). In that test unit stratified multi-component remains to a depth of two metres were uncovered (Wilson 1982:841). To determine age and chronology fauna samples were sent for radiocarbon assays, and dates were returned from the mid-Holocene (Wilson 1982:842). Occasional visits were made to the site throughout the 1980s. In 1983, Meyer submitted an additional radiocarbon date (Meyer 1990:4). Then, in 1989, he returned to Below Forks with Roger Herman and opened a one by two metre unit in the central area of the site (Meyer 1990:9-13). They uncovered multicomponent deposits to a depth of 2.5 metres in this locale (Meyer 1990:16-22). Throughout the 1990's Meyer made several visits to the site. The highlight of these was the discovery by Brad Novecosky in 1999 of an Early Side-notched point in what became the eastern excavation area (Meyer 2002a:6).

In 2000, Meyer returned to the site with funding from the SCAPE Project, supported by the *Social Sciences and Humanities Research Council of Canada* (SSHRC) through the *Major Collaborative Research Initiatives* (MCRI) program. Excavations were opened in two areas (Figure 1.3). In the central area, the 1989 unit was reopened and a trench of seven metre units was dug along the 135 E survey line (Meyer 2001). In the eastern area, six one-metre units were excavated (Meyer 2001). An additional one by two metre test unit was started at the toe of the valley slope in the far western portion of the site to investigate stratigraphy and the extent of the site (Meyer 2001). An additional excavation occurred in the slump just below the central area. In 2001, the central and eastern two block excavations were expanded into blocks, with 15 metre units opened in the eastern area. Also, 15 units were opened in the central area (Meyer 2002a). Additional excavation locales included the reopening and deeper excavation of the original 1980 test unit and continued excavations of the unit at the toe of the slope (Meyer 2002a). In 2002, excavations continued in the central area to finish units open in 2001 (Meyer 2002b:4-6). A total of 53 square metres were excavated. Of which 22 square meters were excavated in the eastern area, 27 in the central area, and 4 units were positioned in the western portion of the site. The site was visited in 2003 by the principal researchers of the SCAPE project. Backfilling and profile description of the central area were concluded in this year.

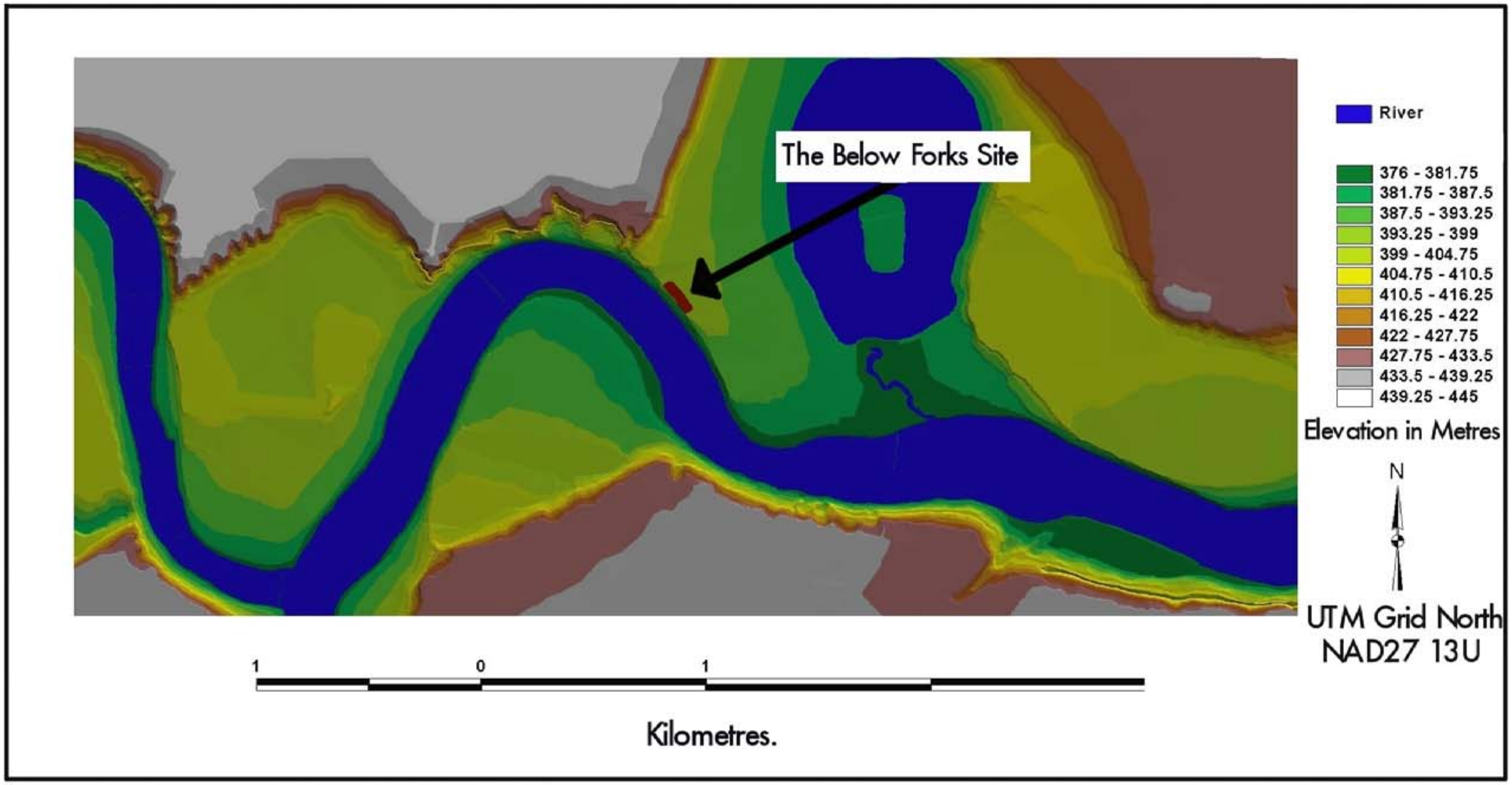


Figure 1.2. The location of the Below Forks site on a digital elevation model.

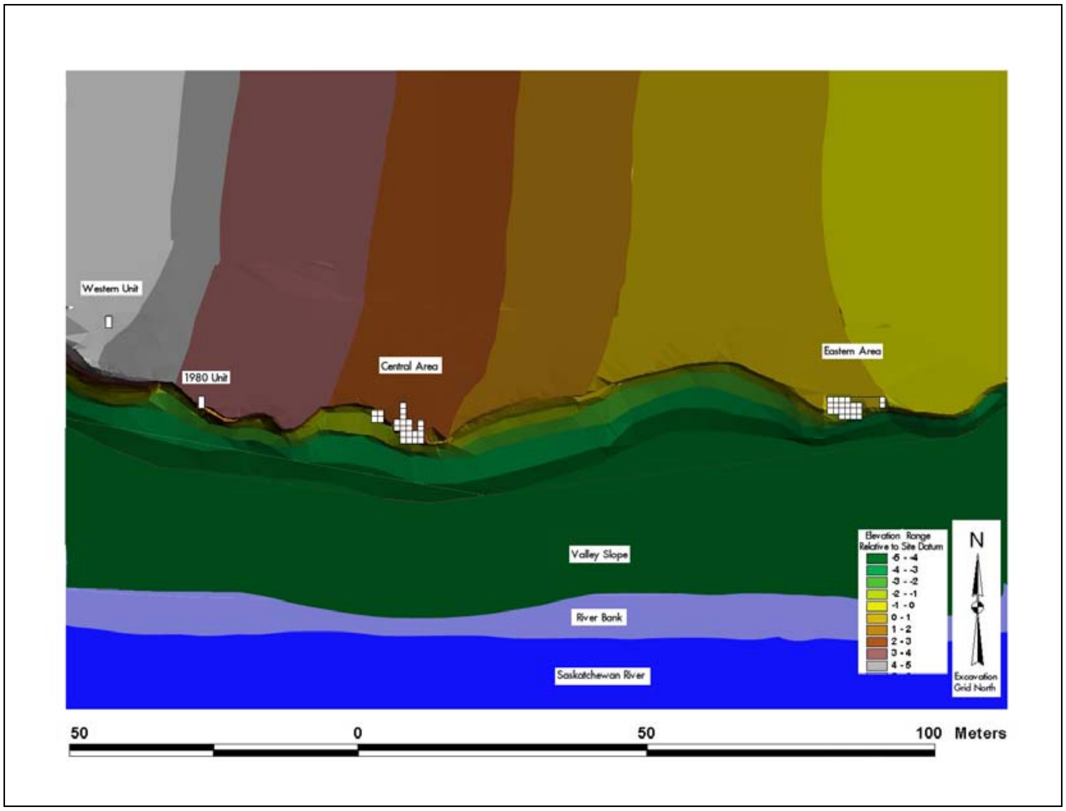


Figure 1.3. The position of excavation units.

1.5 Problems in the Excavation and Mapping of the Below Forks site.

Difficult problems for the excavation and geophysical mapping were presented by the site. Access was very difficult, large equipment could not be moved across the river, and only people with hand tools could cross. The scale of the site is large, in terms of spatial extent and in terms of the geomorphology. The site matrix was carbonate enriched and difficult to excavate. Changes in the South Saskatchewan river confound changes in the North Saskatchewan drainage, where two related, but quite different fluvial systems combine to form a third fluvial system in the vicinity of Below Forks. The brush and terrain made foot-surveyed differential GPS (global position system) tracking very difficult. Remote sensing and historical surveys were turned to, namely the engineering topographic surveys made over the course of the Saskatchewan Forks survey (Saskatchewan Power Corporation 1980). These problems combined to limit site excavation and interpretation.

1.6 Position of Site Excavation Units

The 1989 excavation grid was re-established on the 1980 test unit (Meyer 1990:9). The 2000 to 2002 excavation units were placed on a re-established 1989 site grid (Meyer 2001). Fortunately the original iron pins from the 1989 survey were relocated . Figure 1.4 depicts the eastern excavation block.

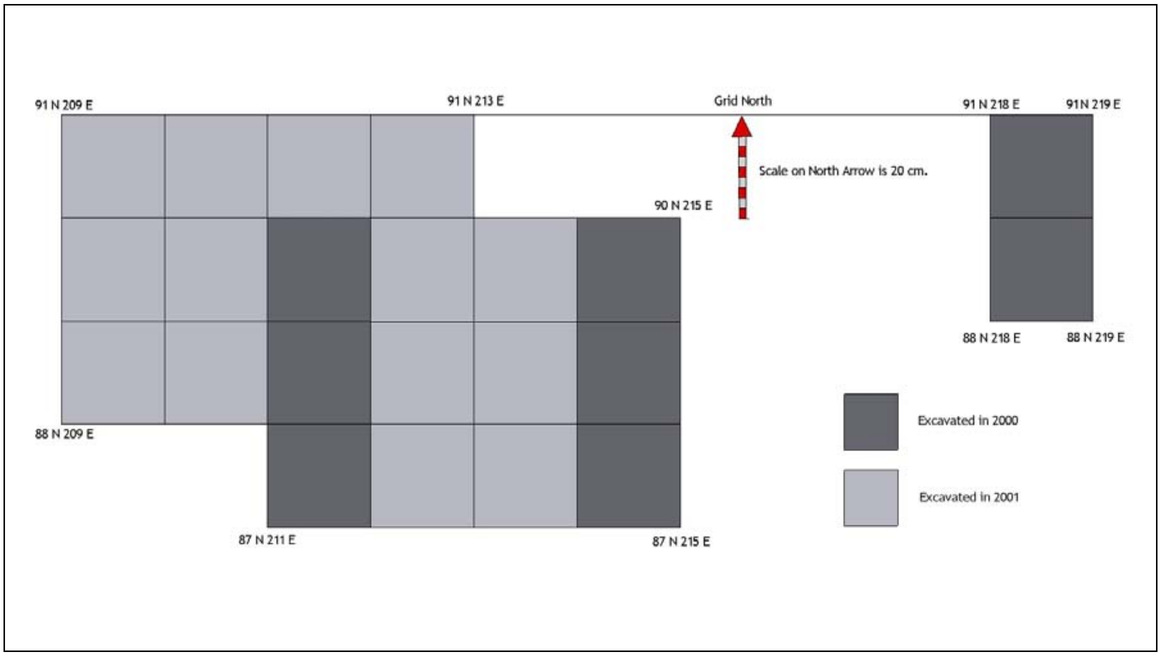


Figure 1.4. Eastern area excavation grid.

1.7 Methods of Excavation and Field Recording

The eastern area of the Below Forks site was excavated with standard and systematic techniques. Single square metre units were excavated to a depth of 110 centimetres below datum in ten centimetre thick arbitrary levels. Two units were excavated to a depth of 120 centimetres. The site was excavated with a combination of trowel, shovel and hatchets. Excavation units were often soaked with water to loosen the carbonate enriched matrix. Units were excavated in 50 centimetre quadrants, where levels zero to seven were screened through 1/4" mesh, and levels eight through twelve with a 1/8" mesh, often with the assistance of a rubber mallet. Artifacts larger than one centimetre were provenienced and mapped onto planviews. Importantly, northing and easting were recorded from the southwestern corner, and depths were recorded as below the excavation block datum. All measurements were taken to the nearest half centimetre. Features were mapped, often cross-sectioned, and a bulk sediment sample was removed. The bulk samples were dry screened in the laboratory through a nested series of screen with mesh sizes 1/4", 1/8", 1/16", and 300 microns. Sediment less than 300 microns was discarded. Photographs were taken of every significant artifact bearing level. Stratigraphic profiles were recorded for every wall, except for the north walls of 88N 211E, 88N 214E, and 89N 218E. Planviews recorded artifact position, artifact type, features, sediment discolourations and the position of the cut-bank edge. In sum, excavation of the site was conducted in a systematic, standard way.

1.8 Thesis Organization

The problem of lithic tool manufacture is addressed in the following manner. Chapter one introduces the site, excavations and the problem of lithic tool manufacture. Chapter two presents background information on the geological, geographical, biophysical and culture history of the region. The site is separated into three occupations in chapter three. It also details the stratigraphy and provides the three dimension context of each occupation. The chapter finishes with a discussion of the radiocarbon chronology for the site. A debitage analysis centred on manufacture technology is presented in chapter four. Chapter five contains a tool analysis and extended discussion of diagnostic artifacts. Chapter six provides an analysis of cores and miscellaneous lithic artifacts from Below Forks. The lithic analysis is used in chapter seven to interpret the nature of spatial activity present at the site. Chapter eight presents a summary of tool manufacture and concludes the work. Throughout the thesis there are many figures to illustrate the work and a large appendix is provided for comparisons by other researchers.

"E vidi lume in forma di rivera
Fluvido di fulgore, intra due rive
Dipinte di mirabil primavera."

"And I saw light in the form of a stream
Of resplendent brilliance, in between two banks
Painted with all the marvels of the spring."
Dante Alighieiri, from the Paradiso,XXX:61-63 (1980:483).

2. BIOPHYSICAL AND HISTORICAL OVERVIEW

2.1 Geoarchaeological Summary

Deglaciation in the region occurred before 11 500 rcybp, and formed a series of proglacial lakes bounded by moraines, namely glacial Lake Saskatchewan, and glacial Lake Agassiz further to the east (Christiansen 1979:916-921,1982; Christiansen et al. 1995:344-346; Christiansen and Sauer 1993; Dyck and Prest 1987; Ellis and Clayton 1970:34; Klassen 1989:157-161; Simpson et al. 1990:11). A major delta of glacial lake Saskatchewan, named the Fort a la Corne delta, was created (Christiansen et al. 1995:346; Simpson et al. 1990:11-12). As glacial Lake Saskatchewan drained, the present Saskatchewan River channel formed, initially rather quickly (Christiansen 1979:233; Schreiner 1983). The Fort a la Corne delta was reworked into aeolian dune fields over the Holocene (Kozak et al. 1968a, 1968b; Simpson et al. 1990:12). The North and South Saskatchewan rivers formed independent terrace sequences (Christiansen 1982:51; Freeman and Roskowski 2002). At the forks, these two fluvial systems merge to form a third system, making it difficult to interpret river valley development such that stages of river development are indistinct.

The Below Forks site is situated on an alluvial slope, at an elevation of 15 metres above the modern river level as measured by the Saskatchewan Power Corporation (1980). The valley top is 55 metres above the modern river level. Thus, the site is located on a middle level of the slope in a position indicative of antiquity in the mid-Holocene. The site exhibits point bar development and overbank flooding, capped by loess-like cliff top deposits (Meyer 1990:5,13). The point bar appears as a "lateral/vertical accretion package" (Laura Roskowski, personal communication November 19, 2003). The sequence of depositional history has some exceptions, since "Alluvial, aeolian, and colluvial sediments make up the vertical portion of the feature" (Laura Roskowski, personal communication November 19, 2003). This includes evidence of rills running down the valley slope, and a possibility for aeolian deposits from nearby dune fields (personal observation).

Mid-Holocene archaeological sites are often situated on middle level slopes and terraces of major river valleys (Running 1995). The Gowen I and II (Walker 1992), and Norby (Zurburg 1991:6) sites are located on the Saskatoon terrace of the South Saskatchewan river. The East Village Access site in Batoche National Historic Site (Kasstan 2003; Lunn 1987; Nieuwhof 1987; Proch 1986) and the St. Louis site (personal observation) are located on a mid-level terrace of the South Saskatchewan River. Caution is required in interpreting this pattern due to site reconnaissance bias. Without the extensive cut bank erosion, the Below Forks site would not have been discovered with modern archaeological survey techniques.

2.2 Context of the Site.

The site components were in relatively undisturbed primary contexts since intact features and definable activity areas were uncovered. Activity areas include a lithic reduction workshop, some habitation debris and spatial concentrations of microdebitage. Microdebitage are flakes smaller than six millimetres in length (Clark 1986; Fladmark 1982). In erosional contexts microdebitage is absent, as suggested by Baumler (1985) and Behm (1983,1985). Early stage rotational slumping and cracking of strata has occurred in the central area (Meyer 1990:6). Rodent disturbance has mixed some of the materials in the eastern area.

The location of the river at the time of occupation remains unknown, but it is hypothesized that the site was positioned on the former floodplain. The procurement of lithic cobbles from the river bank and transportation to the site suggest that the river was close, as it is unlikely that the cobbles were transported any great distance. Similar situations where transport costs are a factor were discussed by Beck et al. (2002).

Faunal remains indicate that a parkland like environment may have existed at the time of the lowest occupation. In particular, a parkland-like environment is suggested by the presence of bison and elk. Although awaiting confirmation, fetal bison elements indicate that the site was occupied in the late winter or early spring. The site locale was probably attractive for people due to the access to resources. Most importantly, the site was in proximity to water and lithic cobbles utilized in stone tool manufacture. A patchy ecology of river valley, uplands and sand dunes were represented in the catchment area. Therefore, a broad spectrum of faunal resources were readily accessible. The site locale provided access to shelter, water and firewood. Site location on a south-facing slope made sense if it was occupied in late winter or early spring. In early spring the slope would have received more sunlight, a slightly earlier spring melt, and was a generally more attractive place to camp than on the other side of the river. Importantly, river cobbles were more accessible for collection since the snow melted earlier than on the south side of the river.

2.3 Eastern Area Step Trench Profile.

The author excavated a step trench below the eastern area to address the depositional process affecting the site. Its profile indicated a sequence of channel and point bar development, with alternating vertical and horizontal accretion. The profile, as illustrated in Figure 2.1, presented a general fining upwards sequence, with channel, point bar development and overbank flooding, all of which was capped by cliff top aeolian deposits. This stratigraphic sequence is related to river valley incision. Table 2.1 presents the rate of river incision. Thus, fluvial processes were expressed in the step trench stratigraphy.

Table 2.1. Rate of river incision.

	Elevation Change To Modern River Level	Time in Millennia	Rate of Incision
Valley Top	50 m.	10 Ky.	5 m/Ky.
Lower Occupation	13 m.	6 Ky.	2.2 m/Ky.

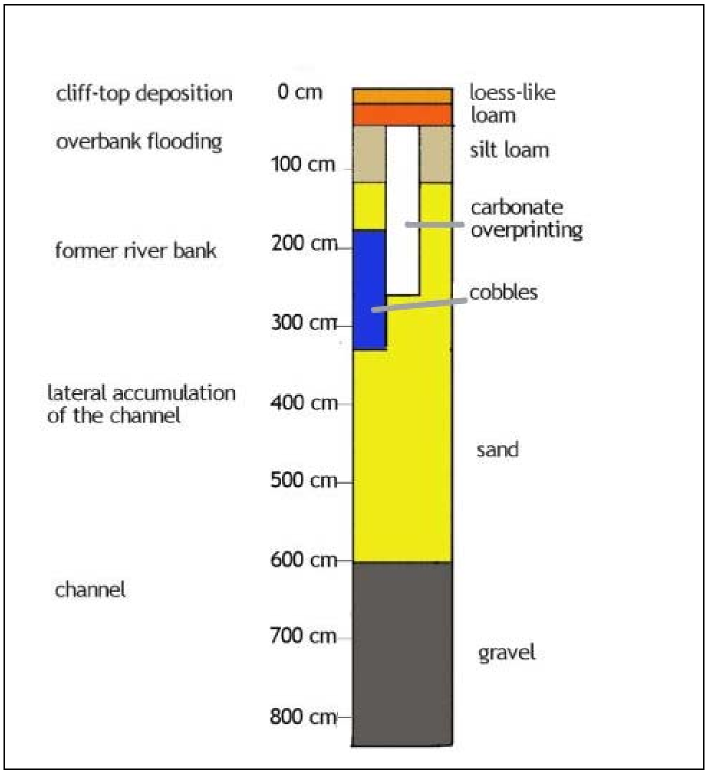


Figure 2.1. Eastern area step trench profile.

2.4 Eastern Area Excavation Profile.

A multicomponent stratigraphy was present in the eastern area (Figure 2.2). Three cultural occupations were present: an upper, middle, and a lower. An upper occupation was located in the cliff top deposits and in the first A-horizon (0 to 20 cm DBD). The floor of the occupation is the boundary between the loess-like cliff top deposits and upper A-horizon. The middle occupation was located in a red/orange horizon located 30 to 60 cm DBD. This red/orange horizon is a vivid stratigraphic marker across much of the eastern area of the site. It's origins remain unknown. Although, various hypothesis of formation have been proposed. These hypotheses include: soil discolouration due to forest fire activity, a possible relationship between soil formation processes and groundwater chemistry, and as a consequence of past human activity. The actual formation process of this horizon remains uncertain. A carbonate rich horizon was present below the middle occupation. A significant dark paleosol was present at a depth of 65 to 75 centimetres below datum. This horizon likely represent s a long period of landscape stability in the eastern portion of the site. Importantly, archaeological remains were not associated with this horizon. It also has abundant evidence of rodent disturbance.

The lowest occupation, while relatively shallow at 80 to 120 cm DBD, was situated in a leached paleosol overprinted by carbonates. Carbonate enrichment is a separate, but related process to soil formation (Birkeland 1984:138-141).   Presence of abundant carbonates in the matrix is a function of age. The same sort of carbonates and hard concrete-like soil was present in both the East Village Access (Kasstan 2003; Proch 1986:3) and St. Louis sites (personal observation 2002). In the Fort a La Corne area, Schwab-Moe (1987:5-6) noted an association of carbonates with plant communities. The carbonate enrichment along root channels was observed in valley-side exposures in the Fort a La Corne Provincal Forest (Schwab-Moe 1987:6). At Below Forks, a few hypotheses regarding the carbonates at the site were proposed. The carbonates at the site relocated through the matrix (following Birkeland 1984:138-141), and tended to enrich former paleosols. Necessary ingredients of the process were biological activity, precipitation and evaporation that related to significant wind, temperatures and time depth (Birkeland 1984:138-146). Therefore, the carbonates provided indirect evidence of mid-Holocene climate.

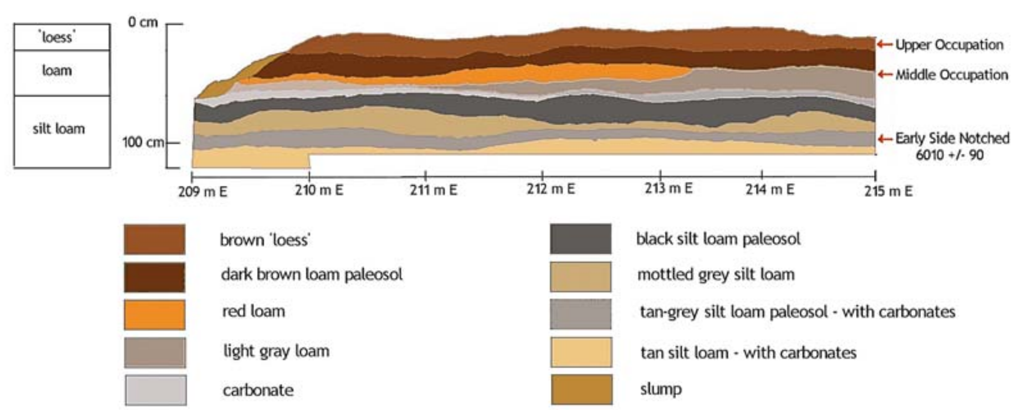


Figure 2.2. Eastern area excavation profile.

Interestingly, the upstream edge of the alluvial slope received more deposition. In the central area, a similar sequence of fluvial sediments was present, with many more paleosols, and a lower occupation with a depth of 2.6 metres (Meyer 1990:13-30; Meyer 2001; Meyer 2002a). Overbank deposition was indicated since strata weld together or pinch out as one travels down-slope; the strata also fined upwards (Rutherford 2002). Colluvial deposition was a concern since the valley slope was located close to the site (Meyer 1990:13). Gravel lenses occurred in the western and central areas of the site, and likely related to rills that flowed down the valley slope. Such strata thicken downslope, and yield a coarsing upwards sequence (Rutherford 2002). These gravel lenses were absent from the eastern area, thus colluvial activity was not a concern in this area. To conclude, fluvial processes are the predominate depositional factors.

2.5 River Flooding.

The North and South Saskatchewan rivers had different responses to environmental change, specifically with regard to flooding and aridity. As to flooding:

> Volume of flow in the Saskatchewan River varies from year to year and from season to season within one year. The volume of high water may exceed that of low water by 100 fold. Normally two flood periods occur, one in spring and one in summer (Reed 1962:45).

Table 2.2. Flooding and low flows of the Saskatchewan rivers

Expected High Water Flow of the Saskatchewan Rivers		
Year Interval	Flow of the South Saskatchewan At St. Louis *	Flow of the North Saskatchewan At Prince Albert
Mean Flow	213 m^3/second	242 m^3/second
1 in 2 year flood	Unknown	1170 m^3/second
1 in 10 year flood	2010 m^3/second	2360 m^3/second
1 in 25 year flood	3640 m^3/second	3270 m^3/second
1 in 50 year flood	4390 m^3/second	3980 m^3/second
1 in 100 year flood	5180 m^3/second	4870 m^3/second
1 in 500 year flood	6800 m^3/second	7560 m^3/second
Reference	Lamers (1988:7)	Lamers (1988:14)

*Eliminating the Lake Diefenbaker buffering effect (i.e. the lake is full when a flood begins).

Expected Low Water Flow of the Saskatchewan Rivers		
Year Interval	Flow of the South Saskatchewan At St. Louis *	Flow of the North Saskatchewan At Prince Albert
Mean Flow	213 m^3/second	242 m^3/second
1 in 2 year drought	130 m^3/second	235 m^3/second
1 in 5 year drought	70 m^3/second	188 m^3/second
1 in 10 year drought	53 m^3/second	169 m^3/second
1 in 20 year drought	47 m^3/second	157 m^3/second
1 in 50 year drought	44 m^3/second	147 m^3/second
1 in100 year drought	43 m^3/second	142 m^3/second
Reference	Pentland (1988:30)	Pentland (1988:8)

*Eliminating the Lake Diefenbaker buffering effect (i.e. the lake is empty when a drought begins).

Two normal flood periods occur for the Saskatchewan River; the first is the snowmelt runoff in spring (April), the second is a peak glacier melt and/or rainfall in the summer (June to August) (Reed 1962:7). Flow volumes of historical floods of the Saskatchewan rivers are presented in Appendix 1.

During the mid-Holocene the South Saskatchewan River was more susceptible to increased aridity than the North Saskatchewan. Confounding matters is that environmental changes in the Rocky Mountains, the source area of these rivers, can greatly influence river flow. The flow of the North Branch can drop 40 percent from mean flow during peak aridity (1 in 100 years), while the South Branch can drop 80 percent from the mean (Pentland 1988:8,30). Thus, the South Saskatchewan River may have been more susceptible to drought/aridity than the North. The impact of increased aridity on the main Saskatchewan River, below the confluence, is uncertain. This situation warrants future research.

2.6. Environmental Overview

The Below Forks site is located in the modern transition zone between the Boreal Mixed-Woods Forest and Aspen Parkland (Ellis and Clayton 1970:50-52; Marles et al. 1999:15; Rowe 1972:32; Zoltai 1975). The most important trees are white spruce, black spruce, tamarack, jackpine, trembling aspen, balsam poplar, white birch and willows. White spruce prefer north facing slopes of river valleys and are tolerant of a variety of soil and moisture regimes (Zoltai 1975:4). Black spruce are "restricted to very wet, peaty sites" (Zoltai 1975:4), often associated with bog floras of sphagnum mosses and heath. Tamarack are "restricted to wet sites, and growing in association with willows shrubs and sedges, or black spruce" (Zoltai 1975:5). Jack pine are located on sandy, gravelly soils, and dry ridges (Zoltai 1975:5). Trembling aspen, and willows occur in the valley.

The position of the transition zone as identified by Zoltai agrees well with the initial land surveys conducted before major agricultural impacts. Patrick (1883), a Dominion Land Surveyor (DLS) described the local forks area as "Hilly and Sandy, small Pine Poplar and Tamarac [sic]". He also noted the presence of marshes along the Saskatchewan River, including the oxbow behind Below Forks. P.C. Caddy (1883), another DLS, described the area of the confluence as "Undulating and broken, covered with Poplar, Willow, Jack Pine, Spruce, etc..." At least in the Forks locale, the 'transition zone' as identified by Zoltai has some degree of longevity, and was a true indicator of the Parkland-Boreal Forest interface (see Archibold and Wilson [1980] for the nature of pre-agriculture botanical communities). Importantly, white spruce was extensively logged in the region during the early twentieth century (Weir and Johnson 1998). As to climatic regime:

> In the Prairie provinces, the transition zone on the Southern side of the Subhumid Low Boreal Ecoclimatic region is dictated more by moisture stress than by improved growing season temperatures. The boreal forest's four typical conifers - white spruce, black spruce, jack pine, and tamarack - occur less frequently together and become mixed with trembling aspen, balsam poplar, and white birch in a narrow transition zone called the Boreal Mixedwoods (Marles et al. 1999:15).

If moisture was the key factor for floral communities as suggested by Hogg (Hogg 1994:1837-1843, 1997:119-120, 1999; Hogg and Schwartz 1999:1), then increased aridity during the mid-Holocene surely had a regional impact (Beaudoin 1999; Hogg and Hurdle 1995; Vance et al. 1995).

The Saskatchewan River valley buffered environmental change, evident in the relationship between plant communities and elevation relative to the river (Schwab-Moe 1997). The key variables for flora are water, sunlight exposure, and the nature of substrate (Clavelle 1997:15-28; Schwab-Moë 1987:103-106). Even in a dynamic physical landscape the floral assemblage is expected to remain stable due to a strong relationship between elevation, sunlight and plant communities (Bird 1961:14-15). Changes in external factors, such as moisture, would have induced plant species to migrate across elevation along the river valley (Hogg et al. 2000). Figure 2.3 describes the relationship between slope, elevation and plant communities.

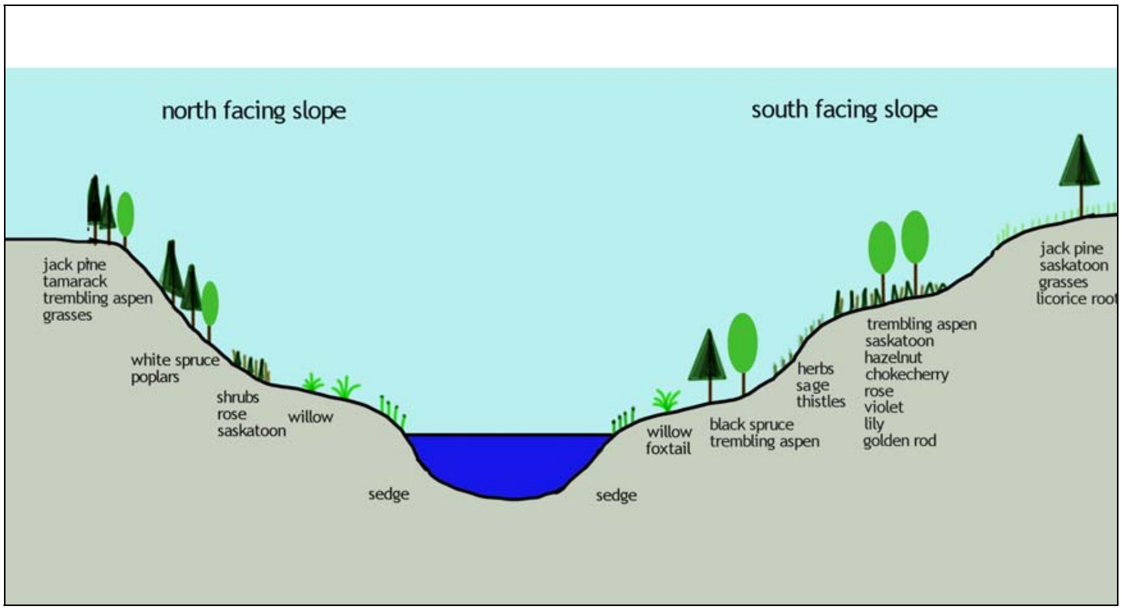


Figure 2.3. Relationship of plant communities to elevation and slope in the river valley (personal observation 2000 and 2001, supported by Pipe [1982] and Schwab-Moë [1987]).

2.7 Faunal Community.

Faunal species in the modern region are diverse and have mixed ecological relationships. The modern site location at the parkland-boreal forest transition has important consequences for the faunal communities. Appendix 2 summarizes faunal species as present in the parklands, boreal forest, and recovered from the Below Forks site. The most important mammals were bison, elk, moose, canids, black bear and beaver. Ground squirrels and other rodents were of taphonomic importance, with the deer mouse, gappers' red backed vole and the meadow vole being most abundant (Pipe 1982). Many species of birds and fish were present in the immediate region of the site. The bird species associated with the Saskatchewan River were identified in Houston and Street (1957). Fish species commonly recovered from the Saskatchewan River were goldeye, northern redhorse, longnose sucker, pike, walleye and common sucker (Reed 1962). Mayfly and caddisfly larvae formed the most important insect communities for fish ecology (Reed 1962:40; Sawchyn 1973).

2.8 Archaeological Floral and Faunal Assemblages.

2.8.1 Faunal Assemblage.

A wide spectrum of faunal species was present in the archaeological assemblage. Bison, canids, beaver, muskrat, and lagomorphs were utilized at the site. Indeterminate bird and fish bones, as well as clamshells were recovered from the archaeological assemblage. Without conducting a formal faunal analysis, I suggest that the archaeological recoveries indicated a generalist faunal resource utilization, with bison as the foremost species. This observation must be tested with a formal analysis.

2.8.2 Floral Assemblage.

Plants were of technological, medicinal and ritual use throughout prehistory (Clavelle 1997; Leighton 1985; Marles et al. 1999). The plant use of the Mummy Cave series is unknown, warranting future research. Carbonized chokecherries, hazelnuts and possible blueberries/saskatoons were recovered from occupations at Below Forks and are possibly of archaeological significance. A careful analysis of seeds recovered at Below Forks is necessary to identify if they are of natural or cultural occurrence.

2.8.3 Archaeological Catfish and Mid-Holocene Climate.

Remains of catfish were identified in the archaeological assemblage from the lower occupation of the eastern excavation area. Of note is that catfish are not extant in the modern river system (Snell 1991). Their archaeological presence indicates environmental change. Drought and aridity had significant effects on aquatic ecology. For the fisheries this meant:

> as water level drops, water temperature increases. In addition, the substrate is exposed to sunlight facilitating the growth of aquatic plants. Plants, through the process of respiration, require oxygen but as water

> temperature increases, there is a corresponding decrease in the dissolved oxygen content (Piper et al. 1982:6).

A multitude of drought-related effects influence fisheries. These include:

> a decreased availability of spawning areas, crowding due to reduced deep water, greater predation by fish, birds and mammals, fish stranded in backwater pools, increased stress and reduced feeding/growth occurred from decreased dissolved oxygen and heightened water temperature, disease and parasites increased, and generally lowered survival rates (Miles and Sawchyn 1988a:157-158).

In this context, the presence of catfish at Below Forks makes sense. Catfish tolerate warm water and decreased oxygen content (Piper et al. 1982:210-211). The key aquatic insect prey species were mayflies and caddisflies (Reed 1962:40). These populations rapidly respond to environmental change. Such a response marginally buffers environmental change for the fisheries. Overall, any significant increase in aridity had major consequences for the river systems and their ecology.

2.9 Environmental Summary.

The paleoenvironment, although its exact nature remains uncertain, was influenced by the river systems. Floral communities were largely buffered by the river and topographic relief, where permanent water insured floral community success, and where species could enjoy and migrate across microenvironments along elevation. The archaeological evidence suggests that a parkland-like environment was present at the time of the lowest occupation. Mid-Holocene climatic episodes had a significant effect on the Saskatchewan river systems, evident in the presence of catfish in the system. Furthermore, the upper branches of the river had differential responses to aridity with the inflow of the North Branch being more stable than the South Branch. The regional impact of former aridity on ecological communities in the Forks Study region remains to be understood.

2.10 Regional Culture History.

The culture history of the Forks region can be separated into two adaptation strategies: plains-centred and boreal forest-centred archaeological cultures. Generally, the culture history is separated into *complexes, traditions,* and *series*, as defined by Dyck

(1983:69). Figure 2.4 presents the radiocarbon chronology of the regional cultural history. This chronology is developed from Wilson and Burns (1999) for early period groups, Novecosky 2002 for middle period groups, and personal observations for late period groups. Notably, Morlan (2003) was referred to and supplemented the chronology. Un-calibrated, normalized radiocarbon dates are the convention used throughout this thesis. This follows the radiocarbon date referencing protocols of the SCAPE project, and for the Canadian Archaeological Radiocarbon Database (Morlan 2003). Appendix 3 discloses the age ranges and reference for each culture group.

The following culture history is developed from the Nipawin, Forks and James Smith archaeological surveys (Burley 1982; Burley et al. 1982a; Burley et al. 1982b; Klimko 1985; Meyer 1983; Meyer and Klimko 1986; Prentice et al. 1983; Wilson 1982). Agate Basin complex, Cody complex, and Terminal Paleoindian series characterize the early period Paleoindian occurrences in the region. The middle period is well expressed in the region with Early Side-notched/Mummy Cave series, Oxbow complex, McKean complex, and Pelican Lake complex manifestations. The late period is identified by Besant complex, Avonlea complex, and Late Side-notched series forms. Ceramic wares indicate the presence of the Laurel composite in the region. A regional occurrence of the Selkirk composite is indicated by sites that contain Pehonan complex ceramic wares. Both the Laurel and Selkirk composites had a strong Boreal Forest connection/adaptation. The early and middle period, and a portion of the late period had a plains adaptation. Obviously there has been interaction between Plains and Boreal Forest groups (Meyer and Epp 1990).

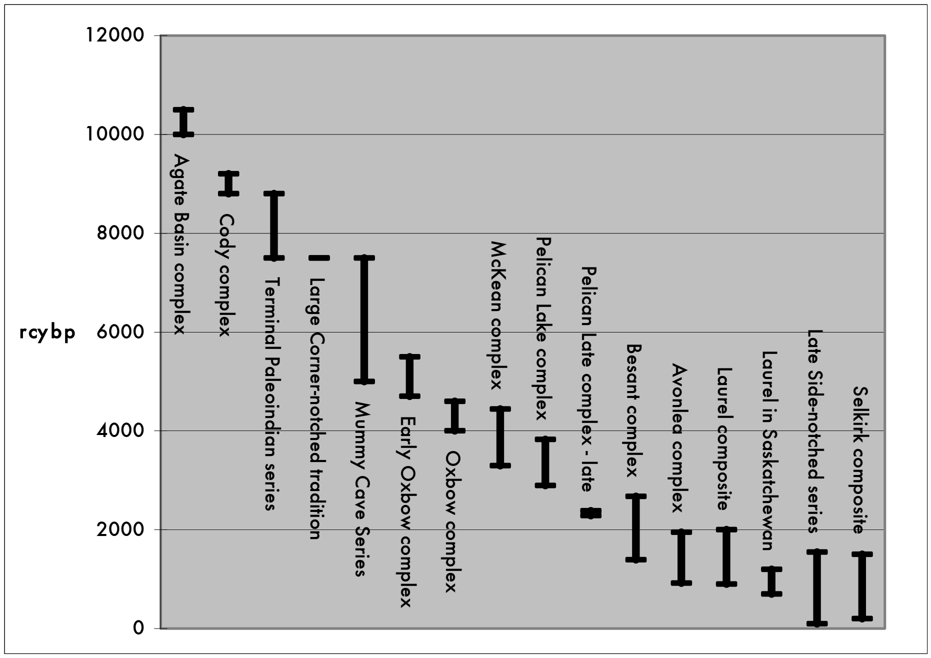


Figure 2.4. Radiocarbon chronology of the regional culture history (Based on Morlan 2003, Novecosky 2002, Wilson and Burns 1999).

2.11 Lithic Technology Summary.

Kooyman 2000:107-127 has presented a fair summary of the lithic technology of the Northern Plains. Supplemental information of importance for the region follows. Gillespie (2002) examined the lithic technology of the early Paleoindian cultures in Alberta. Ebell (1980) has identified reduction strategies of the Agate Basin complex from artifacts recovered from a surface collection at the Parkhill site. Hemmings (1987) studied the debitage from the Horner Site. He noted the importance of soft hammer percussion for Cody complex reduction sequences. Walker (1992) described lithic manufacture technology at the Gowen site. The lithic technology of the Oxbow complex was described in some detail by Dyck (1970;1977) based on the Harder and Moon Lake collections. Low (1996:224-247) noted the bipolar split pebble technology in assemblages of the Mummy Cave series, Oxbow complex, McKean complex, Pelican Lake complex and Besant complex. The importance of the lenticular biface for McKean complex lithic technology is presented in Keyser and Fagan (1993). Hjermstad (1992) noted the presence of a hafted spokeshave in McKean complex sites located regionally in the parklands of Saskatchewan. Quarry sites and collection locales have received some attention. Low (1995a, 1995b, 1995c) examined the Armit River site, and documented in detail the importance of Swan River chert. Stevenson (1985) examined activity patterning of reduction activities at the Peace Point site in Northern Alberta. Bipolar technology is a common feature of archaeological sites of the Boreal Forest, and has been noted in the surveys of Montreal Lake (Forsman 1973), Prince Albert National Park (Forsman 1972; Gryba 1974), and the Key Lake project (Meyer et al. 1981:154). A general observation based on the archaeological literature of the Northern Plains is that there is a deterioration in the quality of lithic technology after the early period. Later items leave an impression that less refined reduction occurred. With this stated, innovations, such as split pebble technology, and improvements in knapping quality, like the Avonlea projectile point, occurred.

The nature of material utilization varied over time. The proportion of local to exotic material types for the main cultures are presented in Table 2.3. Local resources were used in the majority of middle and late period cultures (Meltzer 1999). The use of exotic materials was common with the Large Corner-notched tradition (Novecosky 2002) and the Besant complex (Hjermstad 1996). The early period also has significant, but not exclusive, exotic material utilization (Bamforth 2002).

Table 2.3. Local to exotic patterning of lithic sources across culture history.

Culture Group	Local	Exotic	Typical Site	Reference
Agate Basin	50%	50%	Parkhill	Ebell 1980
Cody	75%	25%	Niska	Meyer 1985
Large Corner-notched	25%	75%	Quill Lakes	Novecosky 2002
Early Side-notched	90%	10%	Gowen 1	Walker 1992
Oxbow	>95%	Trace	Oxbow Dam	Greene 1998
McKean	>95%	Trace	Red Tail (Level 13)	Ramsay 1993
Pelican Lake	35%	65%	Sjovold (Level XIX)	Dyck and Morlan 1995
Besant	9%	91%	Fitzgerald Site	Hjermstad 1996
Avonlea	>95%	Trace	Newo-Asiniak (Level 2)	Kelly 1986
Late Side-notched	60%	40%	Sjovold (Level III)	Dyck and Morlan 1995

2.12 The Early Side-notched/Mummy Cave series.

The Early Side-Notched/Mummy Cave series has a range of 7800 to 4500 rcybp in the northern plains (Figure 2.5). For ease of discussion the Mummy Cave series is separated into *early, middle* and *late* time periods. This summary focuses on sites in relatively good context, and have solid radiocarbon dates. Geographically the Canadian Prairies are of most interest. Important sites in the northern plains of the United States are also included in this discussion . The *early* time period is from 7800 to 6850 rcybp. The earliest dates for the northwestern plains, and periphery, occur at the Boss Hill site (Doll 1982) and False Cougar Cave (Bonnichsen and Bolen 1985; Bonnichsen et al. 1986). False Cougar Cave has a mixed stratigraphy and the date on Bitterroot may be associated with a Pryor Stemmed Terminal Paleoindian component. On the eastern periphery of the northern plains, the Itasca (Shay 1971) and Rustad sites (Running 1995; Michlovic 1996) demonstrate thin, side-notched projectile forms similar to the Logan Creek variety. These sites date to 7800 to 7500 rcybp. Circular structures with a central hearth were present at the Rustad site (Michlovic 1996). In central Saskatchewan a Large Corner-notched projectile point style has been identified by Novecosky (2002:122-123). Although undated, he suggests it has an antiquity circa 7500 rcybp. An affinity between the Large Corner-notched projectile point style and Terminal Paleoindian assemblages has been suggested (Novecosky 2002:74-84). This is evidenced by recoveries of spurred endscrapers in Large Corner-notched tradition sites (Novecosky 2002:74-84). Knife River flint was the main material type of the Large Corner-notched tradition (Novecosky 2002:74-84).

On the northwestern plains the Bitterroot (Northern Side-notched) projectile was common from around 7300 to 6000 rcybp. This point form has been recovered from the Stampede site (Gryba 1976), Hawkwood (Van Dyke and Stewart 1985), Mummy Cave (Frison 1991; Husted 2002) and Gap (Reeves and Dormaar 1972) sites. Bitterroot and the Large Corner-notched projectile points were recovered at the Stuart Lake site in Prince Albert National Forest (Hjermstad 2001). The Large Corner-notched point from this site was manufactured from silicified wood (Hjermstad 2001). Importantly, the Large Corner-notched projectile point was a cultural expression with extra-regional affinity.

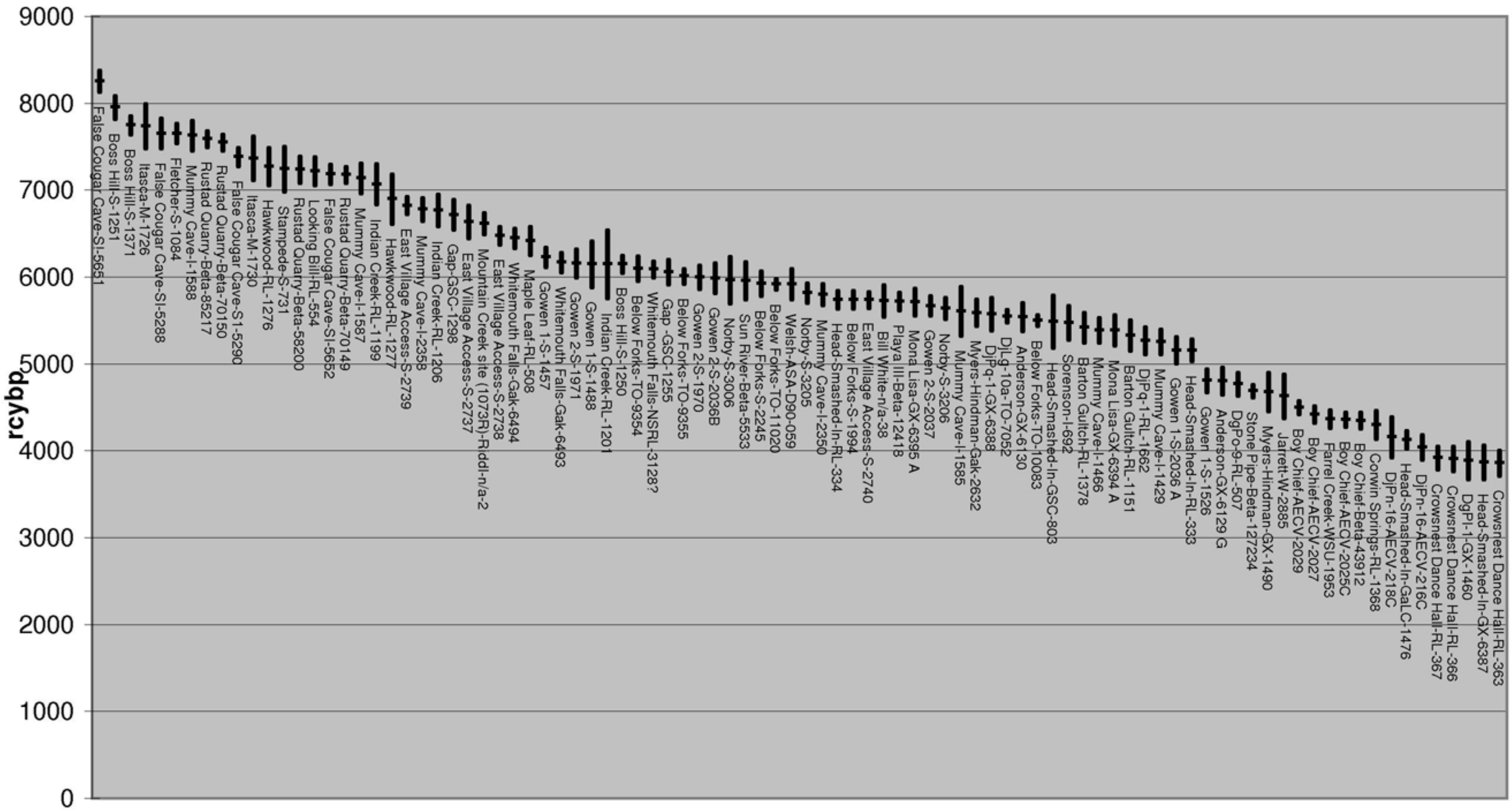


Figure 2.5. Mummy Cave Series Radiocarbon Dates

The *middle* Early Side-notched/Mummy Cave series sites date to 6850 to 5250 rcybp. There are few dated sites from 6700 to 6300 rcybp. Dated sites include the East Village Access site (Kasstan 2003; Nieuwhof 1987; Proch 1986), the Mountain Creek site (Head 1987; Porter et al. 1988; Wilson 1987), the Maple Leaf site (Driver 1985, 1987) and the Whitemouth Falls burial (Buchner 1979; Buchner and Pujo 1977; Ens 1998). Two significant environmental events occurred between 7000 and 5000 rcybp. First was the cataclysmic Mount Mazama eruption, circa 6850 rcybp (Bacon 1983; Druitt and Bacon 1986). Second was the general peak in the Hypsithermal climate interval between 7000 to 5000 rcybp (Vance et al. 1995:92). These two occurrences likely influenced settlement patterning and population size (Sheehan 1994,1995,2002), although more research is necessary to fully test this (Meltzer 1999). Of note is that the Hawken side-notched point style appeared around 6400 rcybp in Wyoming (Frison 1978:198-199). The Mummy Cave series flourished between 6300 and 5250 rcybp. For this time period the Gowen (sometimes known as Salmon River) projectile type was the predominant style of Saskatchewan and Alberta (Walker 1992). It has been recovered at the Gowen sites (Walker 1992), Norby (Zurburg 1991), Welsch (Van Dyke et al. 1991), Bill White (Brumley and Rushforth 1983), Sorenson (Husted 1969) and Stampede sites (Gryba 1976). Bison hunting was prevalent, but other species were utilized in an apparent generalist pattern. The lithic assemblages consisted of local lithic resources (Meltzer 1999) and a common bipolar reduction technology (Walker 1992).

Two separate changes occurred to the Early Side-notched/Mummy Cave series: the development of the Mount Albion and Oxbow complexes. First, in the western high plains the Mount Albion complex developed out of the Mummy Cave series around 5800 to 5250 rcybp (Benedict and Olson 1978). Mount Albion complex material has been recovered from Colorado and represents a high-altitude manifestation of the Mummy Cave series. The key sites of the complex are the Hungry Whistler and 5BL70 sites (Benedict and Olson 1978). Importantly, the Mount Albion complex had a lithic resource use of locally available quartzite and an adaptation centred on mountain sheep. On the Canadian prairies, the form of the Gowen projectile point was transitioned into the Early Oxbow point style (Green 1998:233). Key sites that indicate the transition are the Long Creek (Bryant 2002:228), Oxbow Dam (Green 1998), Gowen 2 (Walker 1992), Gray (Miller 1981) and Sun River (Greiser et al. 1985). The Oxbow complex appears to have been an in *situ* development from the Gowen type of the Mummy Cave series (Bryant 2002:228; Green 1998).

Table 2.4 summarizes the lithic resource and subsistence strategies evidenced at important Early Side-notched/Mummy Cave series sites. Except for an exotic lithic strategy of the Large Corner-notched tradition, the Mummy Cave series has a predominantly locally available lithic resource strategy. Most sites of the Mummy Cave series exhibited a bison oriented subsistence, while others showed broader resource utilization. The differences in subsistence patterns can be attributed to a change in the emphasis on bison utilization rather than from any substantive economic change.

Table 2.4. Significant lithic and faunal strategies from selected Early Side-notched sites.

Site Name	Lithic Strategy	Faunal Strategy	Site Type	Reference
Gowen 1	Local	Bison	Camp	Walker 1992
Gowen 2	Local	Bison	Camp	Walker 1992
Stuart Lake	Mainly Local	Bison?	Camp	Hjermstad 2001
Below Forks	Local	Generalist	Camp/Workshop	Pers. Observation
Rustad Quarry	Mainly Local	Bison	Camp	Michlovic 1996
Boss Hill	Local	Generalist	Camp	Doll 1982
Anderson	Local	Bison	Camp	Quigg 1984
Head-Smashed In	Local	Bison	Kill	Reeves 1978
St. Louis, Level 4	Local	Bison	Camp/Kill?	Pers.Observation
Norby	Local	Bison	Kill	Zurburg 1991
Beaver Creek	Local	Generalist	Camp	Alex 1991
Itasca	Mainly Local	Generalist	Camp/Kill	Shay 1972

2.13 Lithic Technology and the Refugia Hypothesis.

Hurt (1966) proposed the existence of refugias from environmental conditions in portions of the Plains during the mid-Holocene. He suggested that the northern periphery, eastern periphery, areas of high elevation and along glacier fed rivers were more attractive for people, at times, than the prairie as a whole. While there were exceptions, notably Head-Smashed-In (Reeves 1973; 1978), the refugia hypothesis an interpretation for the distribution of mid-Holocene archaeological sites (Benedict 1979; Buchner 1980:201-209; Hurt 1966; Frison 1975:294-296; Meltzer 1999; Pettipas 1996:49-54; Sheehan 1994, 1995, 2002; Walker 1992:125). Alternative models to account for the distribution of mid-Holocene archaeological sites are presented by Mulloy (1958,1954), Wedel (1961) and Reeves (1973). None of the models of mid-Holocene subsistence/settlement patterns are correct (Sheehan 2002:122). Sheehan (1994,1995) has refined the refugia hypothesis to take in to account variation in groundwater stability and environmental change. During the mid-Holocene, bison were the focus of subsistence, although Sheehan (2002:137-138) notes an increase in diet breadth, with a shift towards riverine faunal resources (Sheehan 2002). The Below Forks site with a subsistence/settlement pattern associated with the Saskatchewan River fits the refugia model well. The lithic sources selected throughout the Early Side-notched period appear to have been secondary deposits, mainly of glacial till, often best exposed and accessible along valleys as river cobbles. If there was a preferential subsistence-settlement pattern focused on river systems, the use of river cobble sources of lithic materials would naturally follow.

2.14 Chapter Summary

Chapter two presented the necessary background information about the environment and archaeology of the Saskatchewan Forks region. This chapter has set the context for later site interpretations. A depositional history was presented, where fluvial processes were of most importance. The climate of the mid-Holocene was briefly discussed, as was the nature of flooding and aridity. Important plant and faunal communities were assessed, noting the role of the Saskatchewan River in buffering environmental change in an area of ecological diversity. A general archaeological culture history was presented. Included was a detailed discussion of the Mummy Cave series in order to set the context. The subsistence-settlement pattern of Below Forks was addressed with the notable relationship between lithic resource strategies and settlement patterns with respect to Hurt's (1966) refugia hypothesis.

"Monumentos a cada momento"	*"Monuments to every moment*
hechos con los desechos de cada momento".	*Refuse of every moment, used."*
Octavio Paz (1987), desde	Trans. by Elizabeth Bishop, from
Objetos y Apariciones,	Objects and Apparitions,
y Joseph Cornell.	for Joseph Cornell

3. SITE SCALE ARCHAEOLOGY

3.1. Introduction.

The context of various occupations of the site are identified in this chapter. Analytical separations are proposed and frame later lithic analyses. Occupational separations are established from the analysis of the vertical distribution of artifact types by level. These separations are refined by a three dimensional GIS construct. Boundaries are set and stratigraphic interpretations are improved. Radiocarbon control of these occupations is presented at the end of the chapter.

3.2 Vertical Distribution of Artifact Types by Level.

The analysis of the vertical distribution of artifact types by level was a method to assess the vertical position of multiple occupations. The analysis is summarized on Table 3.1. The site was excavated in 10 cm. levels. These levels were consistently measured below datum. The vertical distribution of artifact types by level described the separation of cultural components. The lower occupation was present in levels eight to twelve. A bimodal distribution of artifacts was present for levels zero to six, an observation suggestive of two occupations. While the majority of each occupation was separable, there was some mixing. Notably, mixing was present in levels three and seven.

Further investigation of the distribution of artifact types by excavation level clarified the distinction between these younger occupations. The upper occupation had an abundance of cores, very little fire cracked rock, few faunal remains, and some lithic debitage. The middle occupation had a sparse recovery of cores, an abundance of fire cracked rock (FCR), and some faunal remains. The weight of debitage described a bimodal pattern for the upper components. A series of graphs depict strong patterns in the distribution of artifact classes by level. Figure 3.1 portrays the vertical distribution of *all artifacts* summarized by weight and frequency. The lower occupation contained a great density of materials. Biases of the lowest component include that the excavation area increased with greater depth, and that a 1/8" screen was used on excavation levels eight to twelve, while a 1/4" screen was used on levels zero to seven. From this situation frequency of all recovered materials was greatly increased in the lower occupation compared to the upper components. Figure 3.2 illustrates the vertical distribution of debitage by weight. A well expressed lower occupation was centred in excavations levels nine and ten. Two separate upper occupation were evident and had foci in levels two and levels four respectively.

Table 3.1. Vertical distribution of artifact types by level.

Level	Total		Fauna		Cores		FCR		Debitage		Raw Bone		Burned Bone	
	Freq.	Weight	Freq.	Weight	Freq.	Weight	Freq.	Weight	Freq.	Weight	Freq.	Weight	Freq.	Weight
0	20	334	3	70.9	0	0	0	0	12	51.3	3	70.9	0	0
1	200	1287	27	32.5	4	878.7	4	85.8	164	288.6	23	30.2	4	2.3
2	495	3925	36	97.3	12	2147	17	258.2	429	1422	31	95.6	5	1.7
3	251	2165	54	98.3	2	141.2	27	1489	167	436.6	39	78.8	15	19.5
4	295	2170	54	79.8	2	21.1	24	1324	215	744.4	41	74.5	13	5.3
5	415	705.4	186	408.1	1	9.4	6	19.8	221	250.7	102	389.2	84	18.9
6	221	256.1	42	21.3	2	32.8	6	19.8	170	181.7	12	7.3	30	14
7	736	879.5	143	88.8	5	68.7	9	20.5	576	684.9	37	50.6	106	38.2
8	2537	1414	650	170.1	8	154.7	24	105.5	1851	971.4	135	57.3	515	112.8
9	12403	7065	6170	1209	24	631.9	85	2267	6113	2461	627	824.1	5543	385.2
10	34048	12564	17301	1750	42	1999	143	1492	16529	5833	1787	521.7	15514	1229
11	4561	2407	2748	342.5	11	822.8	17	389.8	1784	847.6	219	99.65	2529	242.8
12	210	60.8	99	30	0	0	0	0	111	30.8	24	19.4	75	10.6

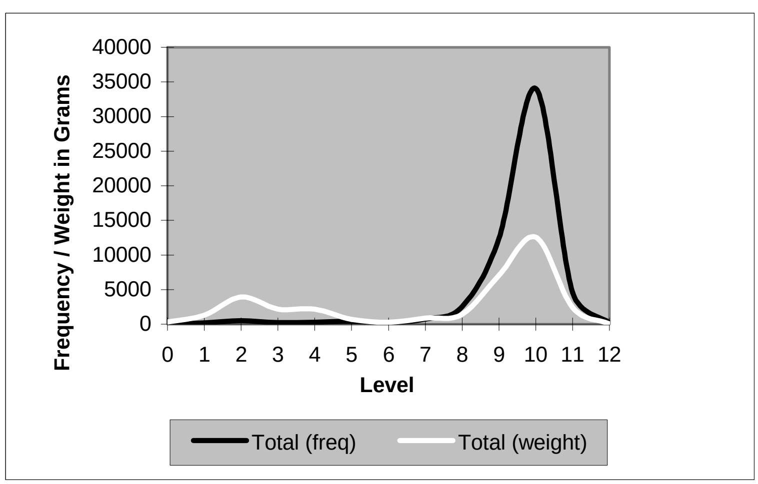


Figure 3.1. Vertical distribution of all artifacts by level

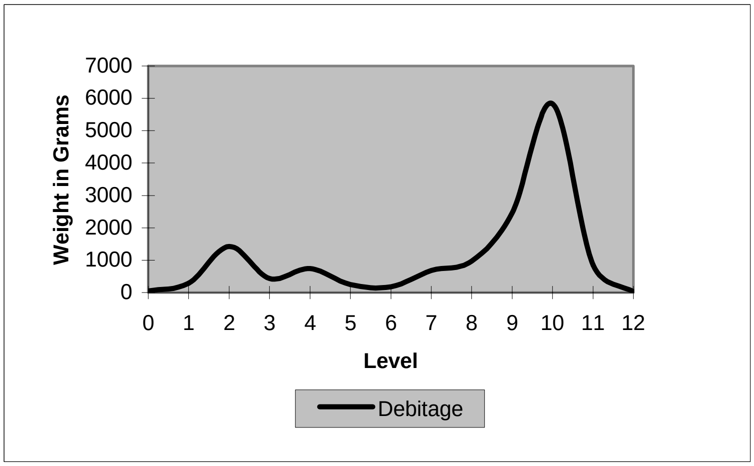


Figure 3.2. Vertical distribution of debitage by weight.

The vertical distribution pattern for cores and FCR is portrayed on Figure 3.3. Of note is that the lower occupation has a strong representation of cores and FCR. Again the upper occupation contained two separate occupations. The upper occupation had many cores and a small amount of FCR, while the middle occupation had much FCR and few cores. Figure 3.4 depicts total, raw and burned faunal remains by excavation level. Large quantities of faunal remains were recovered from the lowest component. More burned bone was present in level ten, while more raw bone was present in level nine. This reflects a pit of burned bone situated below the 'living floor'.

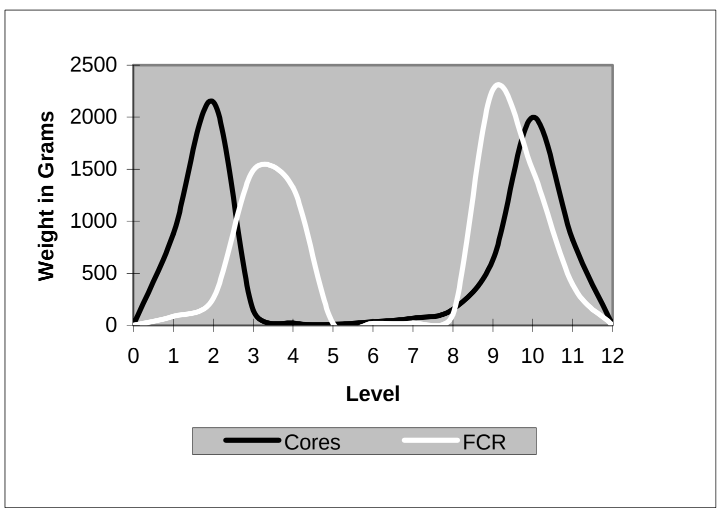


Figure 3.3. Vertical distribution of cores and FCR by weight.

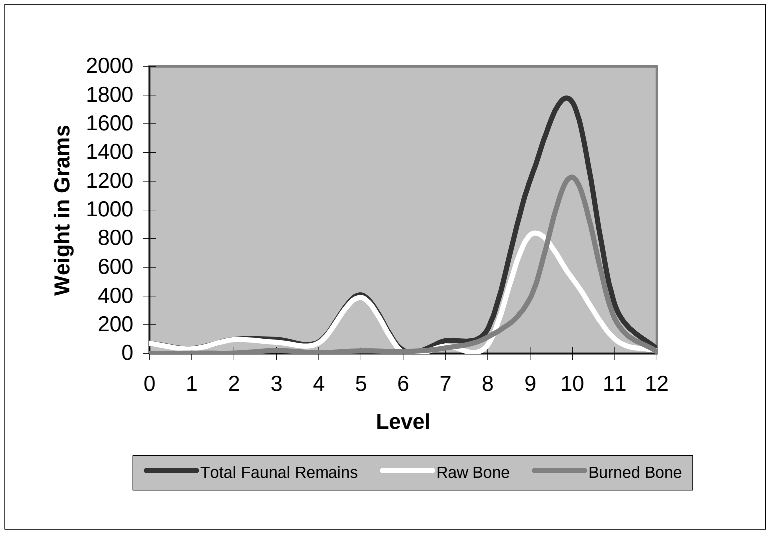


Figure 3.4 Vertical distribution of faunal remains by level.

From the vertical distribution of artifact types by level the following analytical separations were indicated. The upper occupation was situated in levels zero to two. The area between the upper and middle occupation was mixed. To compensate, level three was analyzed separately and acted as a buffer between the upper and middle occupations. The middle occupation was found in levels four and six. Level seven could not be identified as belonging to either the middle or lower occupations. Instead it is analyzed separately acting as a buffer between these occupations. The lower occupation was present in level eight through twelve. To conclude, three occupations were defined, and were separated by the analytic buffers of levels three and seven.

3.3 Three Dimensions.

3.3.1 A Short History of Three Dimensional Analysis.

The interpretation of three dimensional phenomena has a long history in archaeology. Excavation methodologies have been developed to accommodate the 3D nature of archaeological sites. Archaeological interpretation was limited prior to computer-aided modeling. For years, archaeologists have relied on profile drawing to record stratigraphy. Sometimes entire surfaces have been excavated revealing spatial patterning of living floors. In doing so, the elevation of objects on these surfaces was recorded. These types of sites were usually presented in a static two dimensional planview. The three dimensional nature of these sites were often conveyed with photographs showing the extent of excavations. On the whole, three dimensional modeling has been avoided in the archaeological literature. Most often 3D data have been interpreted by plotting of the depths of artifacts onto a stratigraphic profile. These models have been called backscatter maps or backplots, and are essentially side views of site excavations. Before appropriate computer technology was developed, backplots were arduously done by hand through reading the position of an artifact off a catalogue and drawing it onto the profile. The earliest three dimensional computer models were basic automations of the backplot process. Backplots are notably problematic since stratigraphic dips of a living floor are not accounted for. Skew of the backscatter can misidentify the stratigraphic association of components. The first major attempt to use truly three dimensional computer models was by Nelson et al. (1987) to establish individual components within a multi-component site. A guideline to identify archaeological living floors was established from Nelson et al.'s (1987) study:

> If an occupational surface is defined as having a depth as well as extent (in other words, both vertical and horizontal dimensions), and consisting of a scatter of human-manufactured debris (artifacts, debitage, bone waste, etc.) on approximately the same plane surface, it is possible to reconstruct such a surface after excavation by plotting the locations of these items in three-dimensional space, providing that three-dimensional location data were collected during excavation. (Nelson et al 1987:353).

Recently with the advent of accessible GIS technology, the research of three dimensional archaeological forms has intensified. Foremost has been the use of GIS to create three-dimensional surfaces and/or reconstruct entire sites. (Branting and Summers 2002; Hartwell 2002). In continuing with archaeological tradition, these studies mainly assess the context of difficult multicomponent sites (Logan and Hill 2000; D'Andrea et al. 2002). More recently three dimensional models have been developed for individual objects, mainly with the use of 3D scanners(Riel-Salvador et al. 2002). The computer-aided three dimensional analysis of sites is still in its infancy and is developing with the technology.

3.3.2. Three Dimensional Models of Below Forks.

The three dimensional context of the site was recreated with GIS. The goal of the three dimensional construct was to identify cultural occupations and to investigate their nature. Three point provenience data, recorded during excavation, were exported from the *ArchWizard* catalogue, corrected in *Microsoft Excel*, then imported into *ArcView 3.2*. Analysis was conducted with the *Spatial Analysis* and *3D Analysis* extensions.

The site was visualized as a three dimensional backscatter to illustrate vertical distribution. The vertical distribution of artifacts was analyzed by placing the 3D construct on its side and colour coding occupations by level separations presented earlier in the chapter. Figure 3.5 provides the vertical distribution of the three occupations. Of note was a moderate expression of artifacts in the upper occupation, a relatively sparse middle occupation, and a very dense lower occupation. The analytical separations identified from the vertical distribution of artifact types by level were accurate for the occupations.

Stratigraphic boundaries were recreated as surfaces to locate occupational living floors. The stratigraphic excavation profiles were digitized into the 3D construct. Each stratigraphic boundary was converted into a 3D surface. These surfaces were then added to the artifact construct to identify the precise stratigraphic boundary for each occupation. Occupational living floors were defined when the majority of the point provenienced artifacts rested on a stratigraphic surface. The upper occupation was situated at the bottom of the aeolian cliff top deposits (Figure 3.6). The middle occupation was positioned at the bottom of the red/orange horizon, while the lower occupation living floor was located on the bottom of an organically leached paleosol overprinted by carbonates. These surfaces are depicted on Figure 3.7.

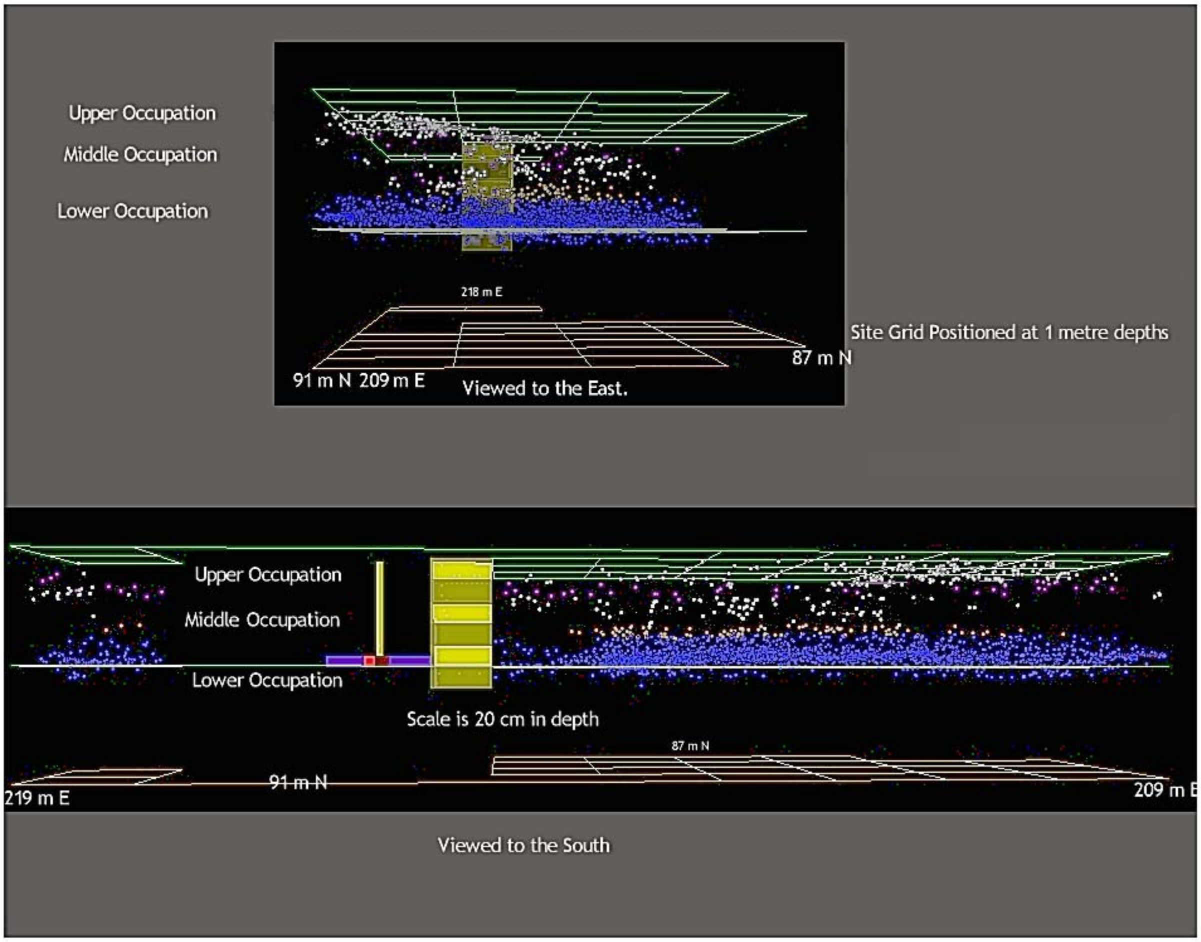


Figure 3.5. Backplot of provenienced items in a three dimensional construct.

Figure 3.6. Occupations marked on an excavation profile photo.

(view is to the east)

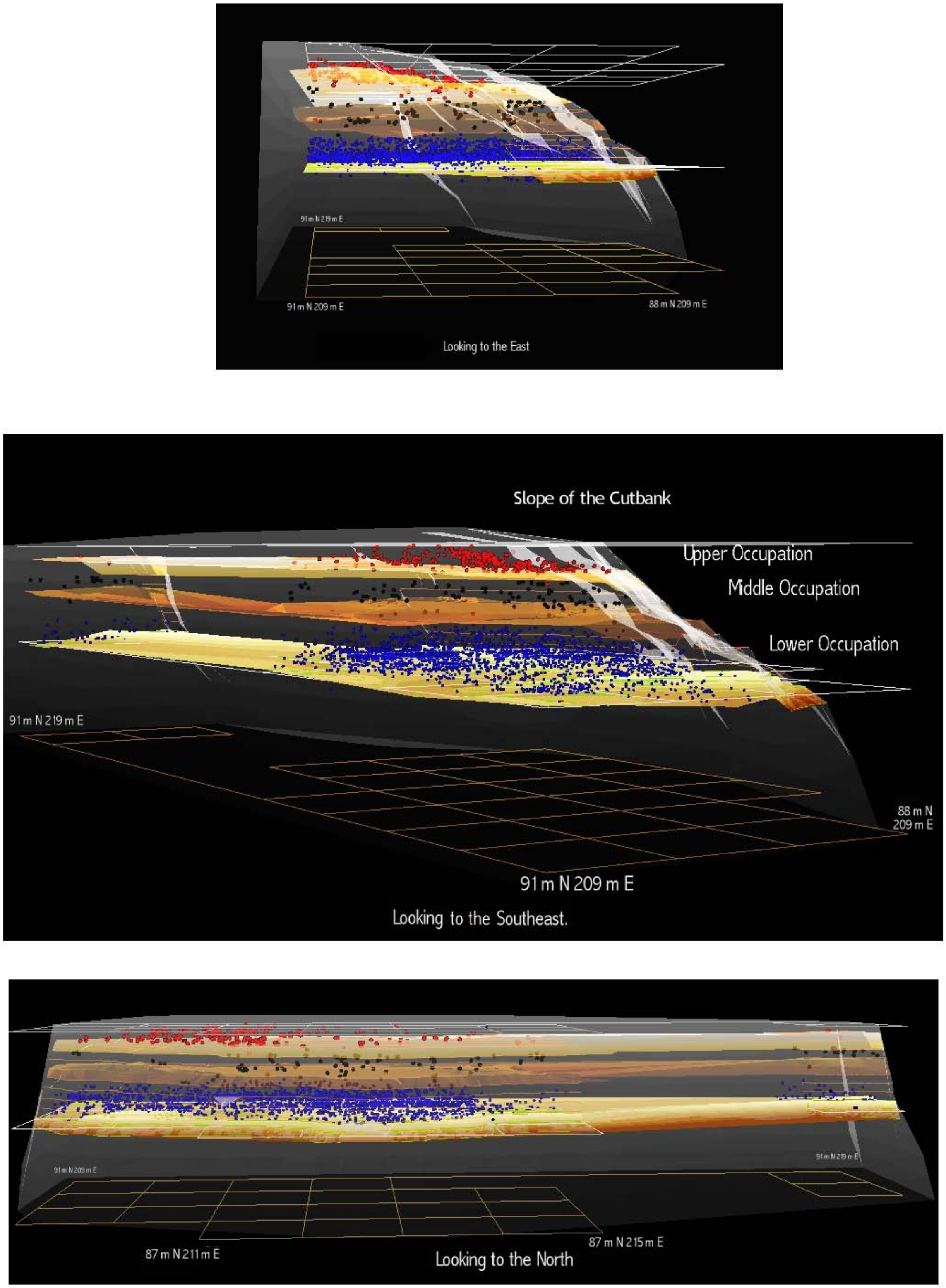


Figure 3.7. The Below Forks site, eastern area stratigraphic boundaries.

The problem of stratigraphic mixing was addressed by creating models of large objects and placing them in the context of modeled occupational surfaces. The idea behind these models was that the base of the large objects should rest on the living floor. These objects were unlikely to have been moved by rodent disturbance, or by trampling due to their large weight and size. Appendix 5 provides detailed methods for object modeling.

The three dimensional model of the upper occupation is illustrated in Figure 3.9. Included in the model is the surface of the living floor, point provenienced artifacts, and large models of objects. The construct indicated a spatial organization of artifacts in an activity area. A reduction workshop of cores, hammerstone, and debitage of all sizes was present (Figure 3.8). Artifacts were most abundant in the northwestern portion of the excavation block.

Figure 3.8. Northwestern corner of upper occupation excavation area.

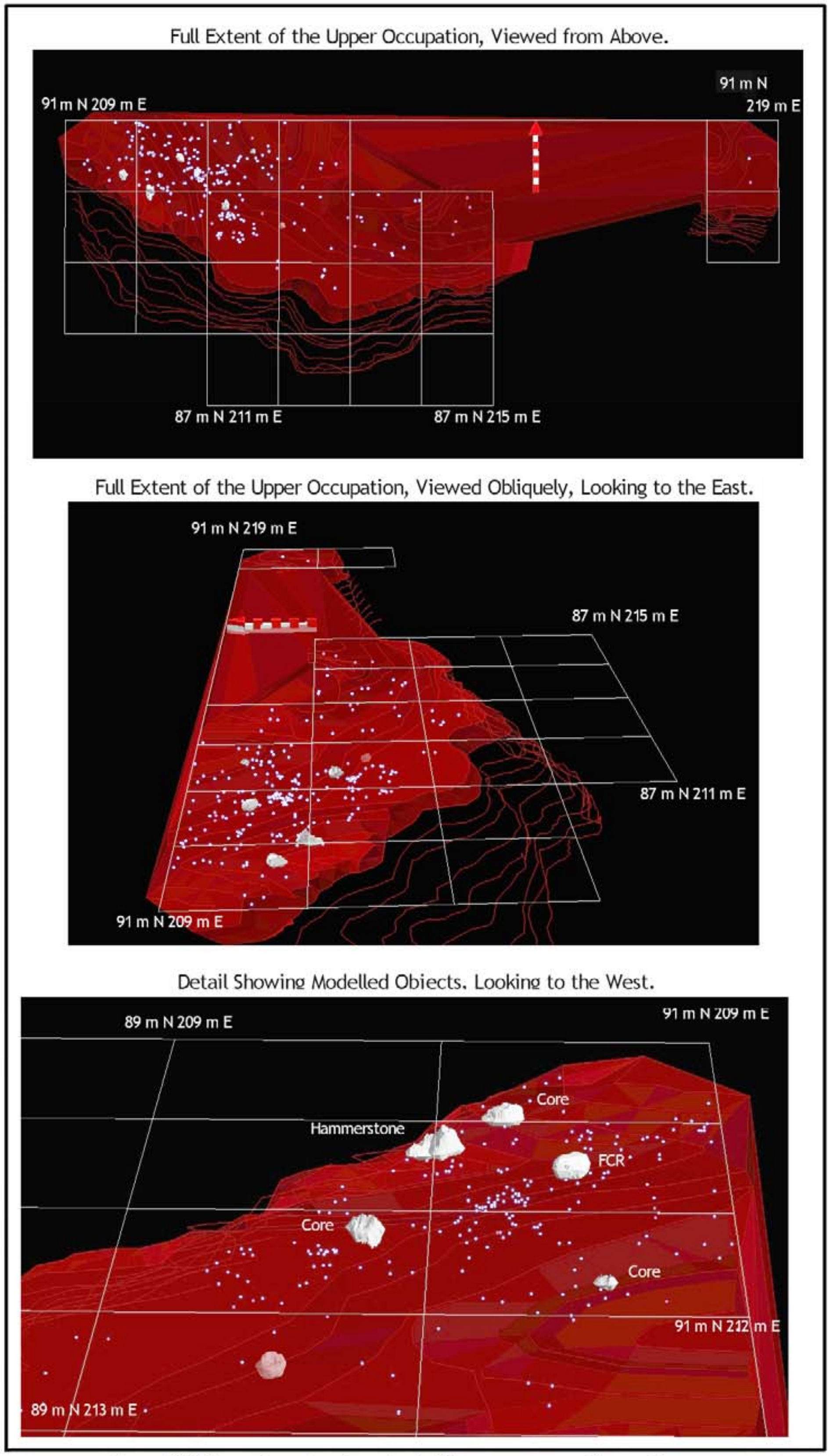


Figure 3.9. Three dimensional construct of the upper occupation, eastern area.

The middle occupation is illustrated as a three dimensional model in Figure 3.11. A living floor was located at the contact between the bottom of the red horizon with a light gray loam. The construct showed sparse artifact density. All of the larger artifacts were faunal remains, consisting of large mammal ribs, and a bison mandible. A concentration of burned bone and FCR was present near the southern edge of the excavation block (Figure 3.10). In the model, this area appeared as a basin-shaped feature.

Figure 3.10. Basin-shaped feature of the middle occupation.

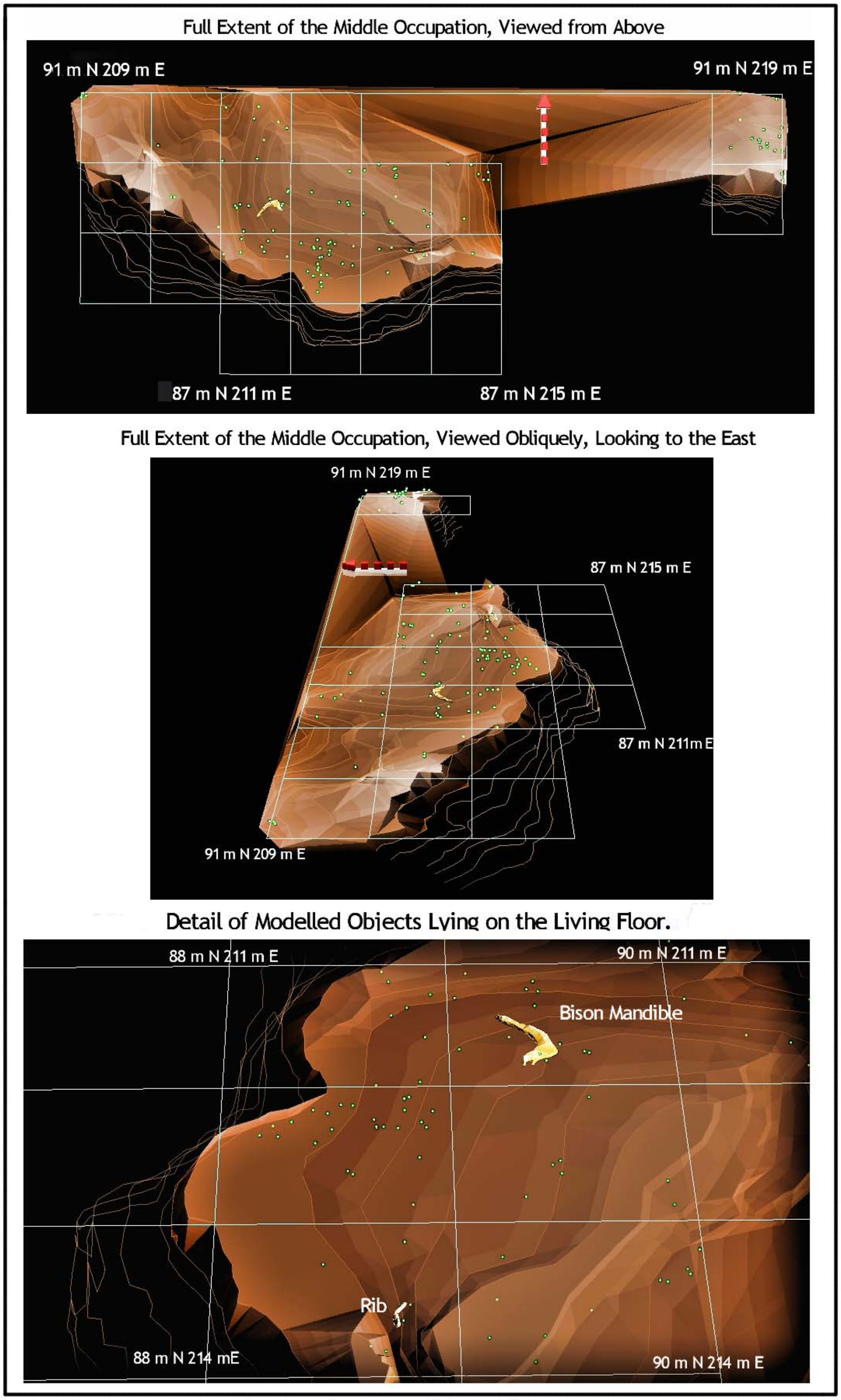


Figure 3.11. Three dimensional construct of the middle occupation, eastern area.

The lower occupation is described in a three dimensional model in Figure 3.13. The model showed great artifact density. Strong spatial patterning indicates activity areas of lithic reduction. Notable was a bipolar reduction focus with a hammerstone, an anvil and nearby cores associated. The large faunal remains were modeled; these include canid long bones and mandible, and lower limb elements of bison. All modeled faunal remains were positioned in the southwestern portion of the excavation block. A pit filled with burned bone is well illustrated in the 3D construct for this occupation (also on Figure 3.12). Materials in the western area of the excavation block appear slightly below the living floor, a pattern suggestive of trampling.

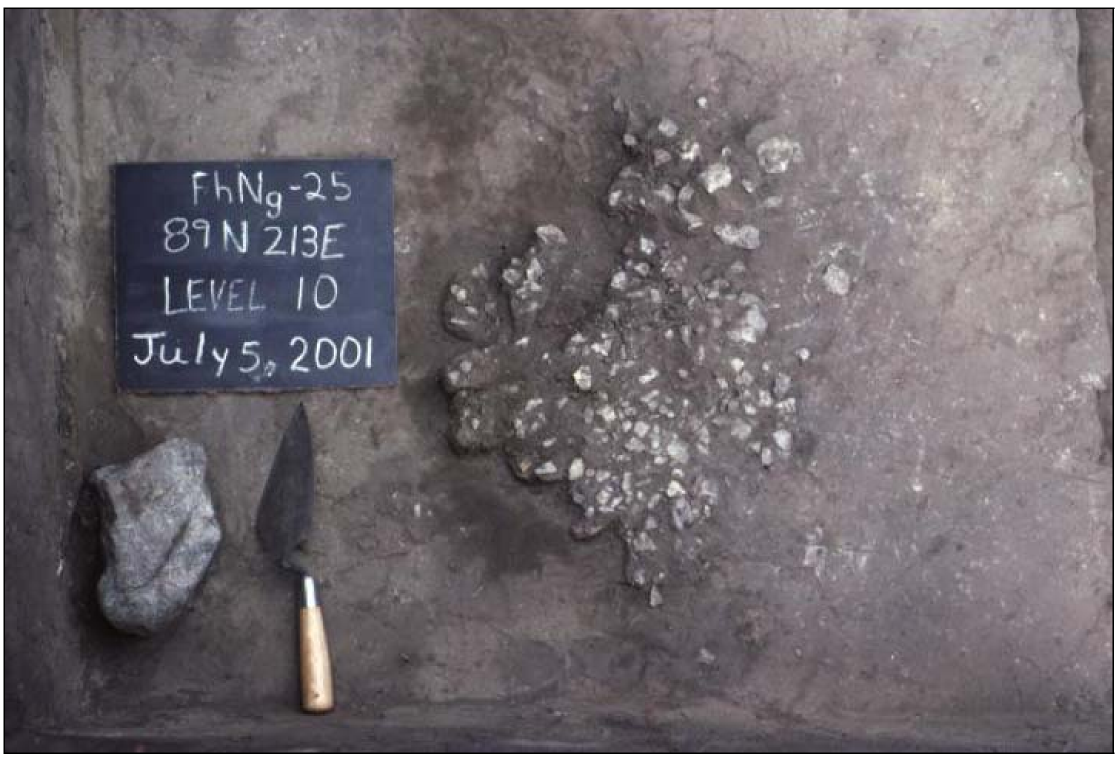


Figure 3.12. Knapping debris feature in the lower occupation.

(A burned bone pit is situated directly below this feature).

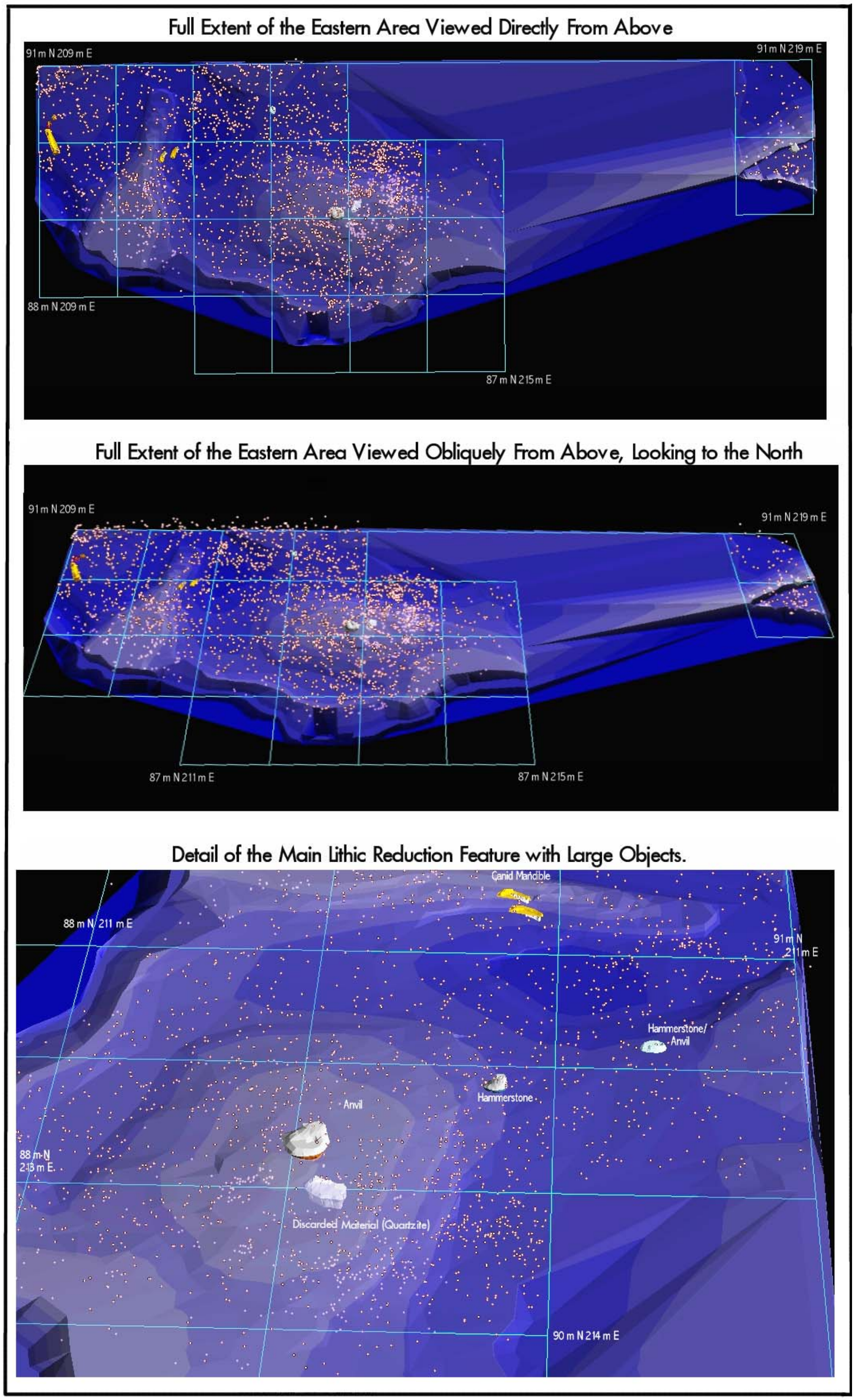


Figure 3.13. Three dimensional construct of the lower occupation, eastern area.

3.4 Radiocarbon Dates.

Radiocarbon dates were submitted from significant horizons of the Below Forks site. The complete list of radiocarbon dates recovered to date is presented in Table 3.2. Radiocarbon samples were submitted from the three excavation areas of the site. This allowed for correlation between these widely separated areas and their occupations. The lowest occupation of the central area and the eastern area have dates usual for the Early Side-notched/Mummy Cave series. Greater stratigraphic separation and chronological control was present in the central area. Notably present were occupations of 3630 +/- 60 rcybp (TO-10194) of unknown cultural affinity, an Oxbow complex occupation at 4750 +/- 90 rcybp (TO-10196), and an early Oxbow complex occupation dated at 4790 +/- 70 rcybp (TO-10085). Problematic was the inversion in the radiocarbon sequence by the date 4790 +/- 90 rcybp (TO-10193) from between paleosols six and seven. This is an indicator that earlier materials were reworked into later strata. In contrast, the upper and middle occupations of the eastern area are of unknown age. These occupations lack diagnostics, and the date obtained from the upper occupation was most problematic. The radiocarbon lab returned a date of –70 +/- 50 rcybp (TO-10082). This date was only possible if a sample of modern bone was submitted. Thus caution is advised not to over-interpret the upper occupation of the eastern area. The eastern and central areas have a lowest occupation of the same relative antiquity, and contain a variety of younger occupations. Compared to the central area, the eastern excavation block has a compressed stratigraphy with tenuous chronological control.

3.5 Chapter Three Summary

The nature of the occupational distributions was assessed with the GIS constructs. These constructs were a means to assess the stratigraphic mixing of occupational materials. This form of analysis established analytical separations and buffers between occupations that were used in later technological analyses. Surfaces of stratigraphic boundaries

Table 3.2. Radiocarbon dates of the Below Forks site.

Rcybp	Deviation	Lab Number	Material	Context	Level	Affiliation
3340	50	TO-10084	Bone	Central area	Paleosol 4	Unknown
4790	90	TO-10193	Charcoal	Central area	Between paleosol 6 and 7	Inversion
3540	70	TO-11020	Charcoal	Central area	Paleosol 11	Unknown
3630	60	TO-10194	Charcoal	Central area	Paleosol 13	Unknown
4570	60	TO-10195	Charcoal	Central area	Paleosol 19	Unknown
4750	90	TO-10196	Charcoal	Central area	Paleosol 20 a	Oxbow
4790	70	TO-10085	Bone	Central area	Paleosol 20 b	Early Oxbow
6100	140	TO-9354	Bone	Central area	Paleosol 21 b	ES-n/MCs
4060	270	S-2034	Bone	1980 test unit	176-183 cm bs	Rejected Date
5740	100	S-1994	Charcoal	1980 test unit	175 cm bs, above lowest occ.	Unknown
5845	140	S-2245	Bone	1980 test unit	Lowest occupation, 176-183 cm bs	Unknown
6010	80	TO-9355	Bone	Eastern Area	Lowest occupation, 100 cm bs.	ES-n/MCs
5520	60	TO-10083	Bone	Eastern Area	Lowest occupation, 100 cm bs.	ES-n/MCs
5920	60	TO-11027	Bone	Eastern Area	Lowest occupation, 100 cm bs.	ES-n/MCS
-70	50	TO-10082	Bone	Eastern Area	Upper occupation	Rejected Date
10930	130	TO-10918	Charcoal	Central Area	3.5 m below surface	Rejected Date

were modelled to reconstruct site stratigraphy. The excavation wall profiles provided source data that were converted into paleo-topographic maps, which were interpolated into surfaces. Occupational living floors were defined when large three dimensional objects and the bulk of the point data 'sat' on a stratigraphic boundary. The upper occupation was situated on the boundary at the bottom of the cliff-top aeolian deposits, the middle occupation was situated on the bottom of the red-orange horizon, while the lower occupation living floor was situated on the bottom of the lower tan/grey paleosol. For the later analysis these analytical separations were important since the site is analyzed by occupation. Levels three and seven are boundaries to buffer zones of artifacts that cannot be accurately placed into an occupational level. The upper and middle occupations of the eastern area are of unknown antiquity, while the lowest occupation has dates of 5520 +/- 60 (TO-10083), 5920 +/-70 (TO-11020) and 6010 +/- 80 (TO-9355) rcybp. Thus the lower occupation of the eastern area fits well within the Early Side-notched/Mummy Cave series. When compared to the central area, the eastern area has a compressed stratigraphy.

"*Every stone a rosetta.*"

Ted Hughes (1998:42),
The Birthday Letters.

4. DEBITAGE ANALYSIS

4.1 Introduction.

A detailed debitage analysis was conducted on materials recovered from the eastern area of the Below Forks site. The debitage was analyzed to fully interpret the lithic technology represented at the site. Significant effort was expended to identify the flake type, detachment techniques, material preparation and flake platform preparations present in the site assemblage. Through a variety of analytical techniques the nature of lithic reduction and production is identified. This chapter presents the sample size and methods of debitage analysis. Then a discussion of raw material type and alteration follows. Included is a discourse on the thermal alteration and thermal shock of raw material. A discussion of various attributes is presented, including flake breakage and termination. Flake types and a metrical analysis are presented. Then a detailed discussion of platform preparation follows, which culminates in an analysis of the relative proportion of reduction stages through the Wright (1980) method. Reduction stage is addressed with a size-grade analysis based on Ahler (1986). The size-grade analysis is further interpreted with the identification of fractal dimension (Brown 2001). Flake initiation is discussed, as is the minimum number of flakes and a testing of the Henry et al. (1976) method to analyze detachment techniques through metrical analysis.

4.2 Methods of Debitage Analysis.

In the eastern block the upper and middle occupations were rather light and mainly produced cores, large decortication flakes, few tools, and little fauna. The lower cultural horizon consisted of a relatively busy occupation floor. Some tools, many cores, and a major amount of debitage were present. The debitage is the most abundant artifact type found at the site and deserves the greatest analytical attention. In order to minimize analysis time only two types of debitage descriptions were conducted. A detailed attribute analysis was performed for lithic artifacts in the greater than one centimetre category. Items in the less than one centimetre category received a minimal description, consisting of just lithic material type, colour (except for Swan River chert), weight, relative size, and the presence/absence of cortex and thermal alteration. The simpler analysis on small debitage greatly reduced analysis time. The detailed debitage analysis focused upon attribute descriptions. Descriptions of each flake were written on a hardcopy form. Appendix 6 presents an example of the form. The hardcopy sheet was set in a systematic standardized way and contained additional notes and a sketch of each flake. The sketch was rather useful, for when the analysis was reviewed, the orientation of each flake and key points of reference were known.

The hardcopy was transferred into the *ArchWizard* computer catalogue based in *Microsoft Access*. The debitage analysis followed the *ArchWizard* catalogue program taxonomy, with qualified exceptions. The taxonomy utilized in the SCAPE project was adhered to, and supplemented with some expanded metrics, quantification of thermal alteration, bulb of percussion form, and some platform characteristics. The additional attributes were included since they addressed specific technological questions. Once catalogued, selected combinations of attributes were searched and summarized, most often in *Microsoft Excel*.

4.3 Debitage: Selected Attributes of Analysis.

A wide variety of attributes were studied from individual flakes. Weight of each flake was documented to a 1/10th of a gram with a digital scale. Lithic raw material type was differentiated. Appendix 7 provides the definitions of various identified raw materials types. The presence or absence of thermal alteration was distinguished, including a 'maybe' category for uncertain designations. The dorsal surface of each flake received some attention such that the percentage of cortex present was tabulated on an ordinal scale, and the number of dorsal flake scars was recorded. Flake termination was ascertained for each flake. Definitions of flake termination are presented in Appendix 8. The longitudinal and latitudinal completion of the flake was recorded, following definitions presented in Appendix 9. Flakes were identified as longitudinally complete, or broken. If broken, the flake portion present was differentiated as proximal, medial or distal. The latitudinal completion was classified as complete, split or broken. If the pieces were split or broken, the side broken was documented. The ventral surface of each flake received some attention. The presence or absence of a bulb of percussion was determined; if a bulb was present it was identified as either pronounced or diffuse. An arbitrary metrical separation differentiated between pronounced and diffuse bulbs. Pronounced bulbs had a thickness at the bulb minus the platform thickness greater than one millimetre. Diffuse bulbs had a thickness ratio less than one millimetre. All metrics were taken with digital calipers, recording to 1/10th of a millimetre. Figure 4.1 illustrates the position of the flake metrics. These include maximum length, maximum width, maximum thickness, platform thickness, thickness at bulb, thickness at middle, thickness at 3/4, width at bulb, width at middle, and width at 3/4. These metrics were only taken on complete flakes. Only maximum length, width and thickness were identified for medial and distal flake portions, latitudinally split or broken flakes, non-orientable flakes and pieces of shatter. Maximum length, width, thickness, platform thickness, thickness at bulb, platform width, and width at bulb were documented for proximal flake portions.

The nature of flake platforms were analyzed in great detail. The number of platform flake scars, the percentage of platform cortex, and the presence or absence of a platform lip were determined. Platform preparations were analyzed, the presence or absence of platform crushing, platform grinding and platform flaking were separately recorded. The shape of the platform was also recorded, using the models shown in Appendix 10. Finally, detachment technique was classified as hard hammer, soft hammer or pressure, and the flake type was determined. The identified flake types were primary, secondary and tertiary decortication flakes, core reduction flakes, bipolar flakes, shaping flakes, bifacial reduction, unifacial reduction, pressure thinning and other. The debitage was analyzed in great detail with an attribute analysis. A benefit of this process was the variety of analytical techniques made available to address specific questions of lithic technology. Specifically, the high quality of the data and the explicit definition of various attribute categories aided analysis. Definition was key (see

Appendix 11); it set up the units and means of analysis, and in hindsight provided a method to validate the research.

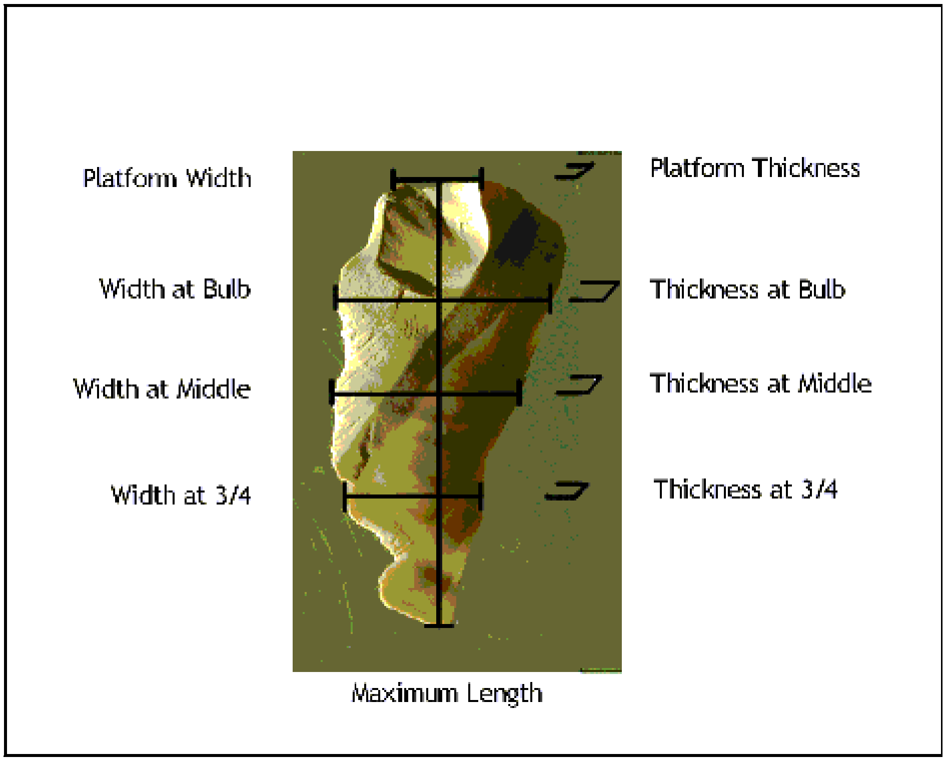


Figure 4.1. Position of the measurements of a complete flake

4.4 Lithic Analysis: Refitting.

Lithic refitting provides general information on flake removals from cores. Refit studies are often conducted to identify the technology of blank production by providing information on the sequence of flake removals from cores. Refitting also provides additional data on the spatial delineation and interconnections of activity areas. Significant refitting of debitage was not done. This avenue of research was not justified with the Below Forks site due to time constraints, and as many cores of differing stages of reduction were recovered, additional analysis of core reduction was unnecessary (Goring-Morris et al. 1998).

4. 5 Lithic Material Utilization.

Of concern was identifying the proportion of local, regional and exotic materials in the site to provide insight into seasonal rounds, and regional and extra-regional interaction (Francis 1983:236-237; Gould and Saggers 1985:122; Odell 1999). Local materials were defined as being available within a site catchment of a two hours walk, arbitrarily set at eight kilometres, from cobbles from exposed or reworked glacial tills. Regionally available materials were identified as from known limited sources occurring within a two days walk from the site, arbitrarily set at 60 kilometres. Exotic materials occur from areas greater than a two days walk. Local materials include Swan River chert (SRC), Red River chert (RRC), Gronlid siltstone, quartzite and quartz. All are locally found in the glacial tills and are well exposed in river cobbles.

Red Willow Creek silicified sandstone is the only regionally sourced material. This named material occurs on Red Willow Creek, some 115 km. East of the Below Forks site. The Red Willow Creek site (FhMt-1) is the only known source of this gray-blue silicified sandstone. It is likely that Red Willow Creek silicified sandstone is also present in the regional glacial tills. However, to date, this material has not been recovered in local till. Until it is found in the till, Red Willow Creek silicified sandstone is herein interpreted as a regionally sourced material.

The relative proportions of raw material in the debitage from the upper occupation is presented in Table 4.1. Swan River chert was the most abundant, while quartz and indeterminate chert were present in limited amounts. The raw materials present in the middle occupation debitage is presented as Table 4.2. For the middle component, SRC is the most preferred material, with other types present in trace amounts. The relative proportion of raw materials from the lower occupation is presented in Table 4.3. Swan River Chert is the most abundant material in this component, while other types are present in relatively limited amounts.

Table 4.1. The relative proportions of raw material types in the upper occupation.

Material Type	Freq.	Weight.
SRC	375	1456.5
Quartz	11	38.4
Indet. Chert	5	25.5
Ironstone	1	6.3
Silicified Sandstone	1	3.6
Other Chert	1	2.5
Limestone	1	1.6
Sandstone	1	0.5
Total	396	1534.9

Material Type	% Freq.	% Weight
SRC	94.7%	94.9%
Quartz	2.8%	2.5%
Indet. Chert	1.3%	1.7%
Ironstone	0.3%	0.4%
Silicified Sandstone	0.3%	0.2%
Other Chert	0.3%	0.2%
Limestone	0.3%	0.1%
Sandstone	0.3%	0.0%

Table 4.2. Relative proportions of raw material types in the middle occupation.

Material	Freq.	Weight
Total	609	1170.3
SRC	571	988.5
Other	7	15.6
Quartz	7	15.6
Ind. Chert	5	9.3
Gronlid	5	2.1
Quartzite	5	130.8
Siltstone	3	2.3
RRC	2	3.4
Chalcedony	2	1.2
Red Willow	1	0.8
Limestone	1	0.7

Material	Freq.	Weight
Total	100.00%	100.00%
SRC	93.76%	84.47%
Other	1.15%	1.33%
Quartz	1.15%	1.33%
Ind. Chert	0.82%	0.79%
Gronlid	0.82%	0.18%
Quartzite	0.82%	11.18%
Siltstone	0.49%	0.20%
RRC	0.33%	0.29%
Chalcedony	0.33%	0.10%
Red Willow	0.16%	0.07%
Limestone	0.16%	0.06%

Material	Weight
Total	100.00%
SRC	84.47%
Quartzite	11.18%
Other	1.33%
Quartz	1.33%
Ind. Chert	0.79%
RRC	0.29%
Siltstone	0.20%
Gronlid	0.18%
Chalcedony	0.10%
Red Willow	0.07%
Limestone	0.06%

Table 4.3. Relative proportion of raw material types in the lower occupation.

Material	Freq.	Weight	Material	Freq.	Weight	Material	Weight
Total	26520	9811.6	Total	100.00%	100.00%	Total	100.00%
SRC	25055	9386.6	SRC	94.48%	95.67%	SRC	95.67%
Quartzite	405	80.5	Quartzite	1.53%	0.82%	Quartzite	0.82%
Gronlid	222	25.6	Gronlid	0.84%	0.26%	Red Willow	0.67%
RRC	132	29.2	RRC	0.50%	0.30%	Siltstone	0.58%
Quartz	120	25	Quartz	0.45%	0.25%	Limestone	0.49%
Red Willow	100	65.9	Red Willow	0.38%	0.67%	RRC	0.30%
Siltstone	87	57	Siltstone	0.33%	0.58%	Ind. Chert	0.28%
Ind. Chert	65	27.8	Ind. Chert	0.25%	0.28%	Gronlid	0.26%
Chalcedony	62	14.1	Chalcedony	0.23%	0.14%	Quartz	0.25%
Basalt	55	20.7	Basalt	0.21%	0.21%	Basalt	0.21%
Limestone	38	47.9	Limestone	0.14%	0.49%	Chalcedony	0.14%
Sil. Wood	6	2.7	Sil. Wood	0.02%	0.03%	Sil. Peat	0.04%
Sil. Peat	4	0.4	Sil. Peat	0.02%	0.04%	Agate	0.03%
Agate	4	3.2	Agate	0.02%	0.03%	Sil. Wood	0.03%
Pebble chert	1	0	Pebble chert	0.00%	0.00%	Pebble chert	0.00%

Table 4.4. Percentages of local, regional and exotic raw materials by occupation.

Occupation	Local	Regional	Exotic
Upper	100%	0%	0%
Middle	99%	1%	0%
Lower	99%	1%	0%*

* indicates exotics present in trace amounts.

Nearly the entire lithic assemblage originated from local sources. Table 4.4 presents the ratios of locally, regionally and exotically available materials for each occupation. Unsurprisingly, as the site was a collection locale, raw materials were predominantly local resources. Regionally available materials were present in limited amounts, in one percent of the middle and lower occupations. The only possible exotic material is a reduced core of silicified wood, and some pressure retouch flakes of silicified peat in the lower occupation. Clearly, the occupants of the Below Forks site had a solid knowledge of local and regional resource sources. A similar point was made by Gillespie (2002:111) regarding settlement patterns by interpreting the relative proportions of lithic material types.

4.6 Thermal Alteration

Thermal alteration of raw material was an important component of the lithic technology of precontact populations. Donald Crabtree first identified thermal alteration while experimenting with different methods to create the lustre he observed on many archaeological examples (Crabtree and Butler 1964). Eventually he discovered that light heating alters raw material. One of the mistaken assumptions of thermal alteration is that it mainly occurred on bifacial blanks. The origins of this bias were modern flintknappers, specifically Crabtree (Crabtree and Butler 1964). It is certain that bifaces were thermally altered, though this was not necessarily the norm.

Purdy conducted the first scientific replication studies of thermal alteration (Purdy and Brooks 1971; Purdy 1974). These studies identified the critical temperature of chert, and defined thermal shock. Mandeville, in a summary of experimental studies of various altered lithic materials, observed that different cherts responded differently to thermal alteration, and that fine-grained material altered at a lower temperature than coarse-grained material (Mandeville 1973; Mandeville and Flenniken 1974). As to the colour shift associated with thermal alteration, McCary (1975:57) noted that the tips of some projectile points turned red, and suspected that this was done for esthetic reasons. Patterson (1975) suggested that the red colour signified a weakened tip due to alteration, a consequence of making material easier to flake.

Five significant physical changes occur to lithic raw material upon thermal alteration. First, thermal alteration improves flaking characteristics, with the caveat that altered material is more easily broken or damaged (Mandeville and Flenniken 1974: 146). Altered material requires more care in working, and a greater amount of platform preparation than unheated material. Verrey noted that:

> altered material work better, but require more care in working – flakes go further, but if platforms are not carefully prepared, or if the extent and direction of the flake are not properly planned, it is very easy to get step fracture and end shock (Verrey 1981:15).

Therefore, a relationship exists between thermal alteration and flake breakage. Second, thermal alteration was observable on surfaces flaked after alteration. Third, a colour change sometimes occurred, happening at a lower temperature than the lustre and knapping quality changes. Fourth, different materials had different critical temperatures.

Fifth, the cores must be heated and cooled slowly, otherwise they undergo thermal shock. Physically, thermal alteration was a significant cultural process to improve raw material for reduction. In turn, there were consequences of thermal alteration.

The physical models of thermal alteration are varied and are summarized by Leudtke (1992). The most important change in the properties of fracture is that altered chert fractures *across* grains of quartz, whereas non-heated chert fractures *around* quartz grains (Leudtke 1992); thus thermal alteration improves the knapping quality of lithic raw material (Crabtree 1967:74). Leudtke (1992:93-94) proposed two models to explain the change in mechanical properties associated with heat treatment: 1) the silica fusion model, and 2) the crack model. Various physical models have been proposed for the silica fusion model, where heating may cause the silica fibres to melt together (Mandeville 1974:201), mineral impurities may form a gel (Purdy and Brooks 1971), and crystal lattice faults get repaired during the heating process (Leudtke 1992:93). The crack model maintains that heating increases microfractures and distributes them evenly, making the raw material brittle, and somewhat controllable (Leudtke 1992:94). Theoretically the quartz grains microcrack, but this has not been experimentally observable. Cracking should occur as quartz and other chemicals expand and contract during the heating process (Leudtke 1992:94). The crack and silica fusion models of thermal alteration are not mutually exclusive, and illustrate a need for additional research into the cultural modification of lithic materials. Interestingly, Turcotte (1986) has shown that rock does indeed microcrack and that this lithic fragmentation process has a fractal nature. Theoretically, thermal alteration should change the fractal properties of lithic fracture. This point is returned to and expanded on later in the chapter.

As lithic material is physically changed through thermal alteration, *flaking technology should change to account for the nature of the material.* Specifically, there should be an increase in platform preparation. The proportion of thermally altered SRC from Below Forks was very high in all the occupations. Tables 4.5 and 4.6 provide the proportion of thermal alteration in the assemblages. Swan River chert has a waxy to glossy lustre when altered (Grasby et al. 2002; Low 1996). Unaltered material has a matte lustre. Colour was of little use in identifying thermal alteration of SRC since this material has great colour variation (Johnson 1986; Leonoff 1970). With that stated, the observation that altered pieces have a white, pink to red colour was generally correct (Low 1996), but not always since grays were often observed. Therefore, for SRC, colour was a poor indicator of alteration, while lustre was an effective alteration marker. The key thermal alteration temperature for SRC is between 350 and 375 degrees Celsius (Grasby et al. 2002:275-283). Red River chert was sometimes thermally altered, best evidenced by potlids spalled off a heated piece. The altered Red River chert appears 'smoked' and has a darker gray colour, but exhibits no lustre change. In all, the thermal alteration of lithic materials was an important part of the lithic technology.

Table 4.5. The thermal alteration of debitage by frequency.

Occupation	% Heated	% Maybe Heated	% Not Heated
Upper Occupation	90%	3%	7%
Level 3	86%	3%	11%
Middle Occupation	88%	2%	10%
Level 7	81%	3%	16%
Lower occupation	82%	1%	17%
Total	82%	1%	16%

Table 4.6. The thermal alteration of debitage by weight.

Occupation	% Heated	% Maybe Heated	% Not Heated
Upper Occupation	68%	1%	31%
Level 3	83%	6%	11%
Middle Occupation	80%	6%	14%
Level 7	81%	4%	15%
Lower occupation	80%	2%	18%
Total	78%	3%	20%

Two observations regarding thermal alteration over time were apparent. First was that, by frequency, alteration slightly increased over time. The second pattern indicated that, by weight, alteration had close to a ten percent decrease in the upper occupation compared to the other occupations. Incidentally, the decrease was likely a sample bias as the upper occupation had larger remains of primary reduction, which skewed the weight ratios. On the whole, the great majority of SRC was thermally altered. Appendix 12 provides the raw data for Tables 4.5 and 4.6.

4. 7 Thermal Shock.

Thermal shock is the destruction of proper conchoidal fracture properties of lithic material due to a failure in the thermal alteration process. Most of what is known about thermal shock comes from mistakes in experimental alteration of materials by modern flintknappers. A variety of thermal changes are known and are summarized on Table 4.7. This chart is a combination of information from Ahler (1983) and Purdy (1974).

Table 4.7. Thermal shock: type, effect and causes.

Type of Thermal Failure	Appearance and Effect	Possible Cause
Block fracture	material fractures into blocky angular chunks, sometimes explosively.	heating/cooling too rapidly, critical temperature of 365 °C for water liquefied under pressure
Potlidding	circular, convex fragments are removed from exterior surface.	heating/cooling too rapidly, differential expansion/contraction
Crazing	multiple complex exterior and interior fractures	temperature was greater than 573 °C, alpha quartz changed to beta quartz.
Calcination	pale chalky colour change, material is very east to crush and grind	very high temperatures were reached, greater than 1000 °C
Distortion	change in form change in volume	unknown cause, but related to a form of shrinkage.

Thermal damage often occurs from heating or cooling too rapidly, where parts of the material contract or expand at different rates. When this occurs the material will potlid or explode. Potlids also occur in relation to freeze-thaw cycles. Notably, cold-weather potlids are broader and have deeper convex fractures. Two critical temperatures of thermal alteration are around 365 $^{\circ}$C and 573°C (Leudtke 1992:93-97). The former is the temperature where water in chert changes form. Under pressure, water will stay in fluid form until a temperature around 365 $^{\circ}$C is reached, at which temperature water in chert becomes vapour. For an item being thermally altered, such a dramatic change may explode the raw material. Raw material must be heated slowly past 365 $^{\circ}$C so that the water can be driven off and the chert does not shatter. The second critical temperature is 573°C. At 573°C the normal crystal structure of quartz (alpha quartz) changes to beta quartz. The beta quartz structure is only maintained when the chert is above 573 °C, when beta quartz cools it reverts back to alpha quartz, "causing irreversible damage to the chert" (Leudtke, 1992:97), and appears as crazing. The crazing of SRC is illustrated in Figure 4.2.

Thermal shock was only observed on materials from the upper occupation. Items were crazed and crenated, hallmarks of thermal shock associated with temperatures greater than 575 °C. These effects were produced by either a failure of the thermal alteration process, or a situation where the material was discarded into a fire. Logically, discard pattern into a hearth is unlikely since chert can explode in a campfire. Therefore it appeared that the material was from a thermal alteration failure. From this observation I hypothesize that thermal alteration technology may have deteriorated over time. This hypothesis warrants future research. The supporting evidence for this would be an increase in the amount of thermal alteration failures, evident by thermal shock. Thermal shock was not formally included in my lithic analysis, instead notes were opportunistically made of pieces with thermal shock. This form of analysis is biased with a 'looking back fallacy' such that the observed deterioration of thermal alteration technology remains hypothetical.

4.8 Debitage Breakage.

The breakage of flakes is an important process that greatly influences debitage analysis. There are a multitude of methods to create the step fracture common in flake breakage. Breakage occurred if insufficient force was applied to the platform, or if the flake lost energy as it was detaching. The result is a flake that snaps off at the point of energy loss. A material flaw, like a bedding plane, may redistribute force, or the material might be too brittle due to thermal alteration failure. Errors in bipolar techniques break flakes. Blows improperly aligned on the core and anvil cause breakage by physical stress, often in the latitudinal centre of the item. This same process can occur longitudinally and cause platform splitting. Flakes can break by trampling on a living floor. Similarly, pounding site matrix through a 1/4" screen with a rubber mallet can break flakes. Also, natural freeze/thaw cycles are known to snap flakes.

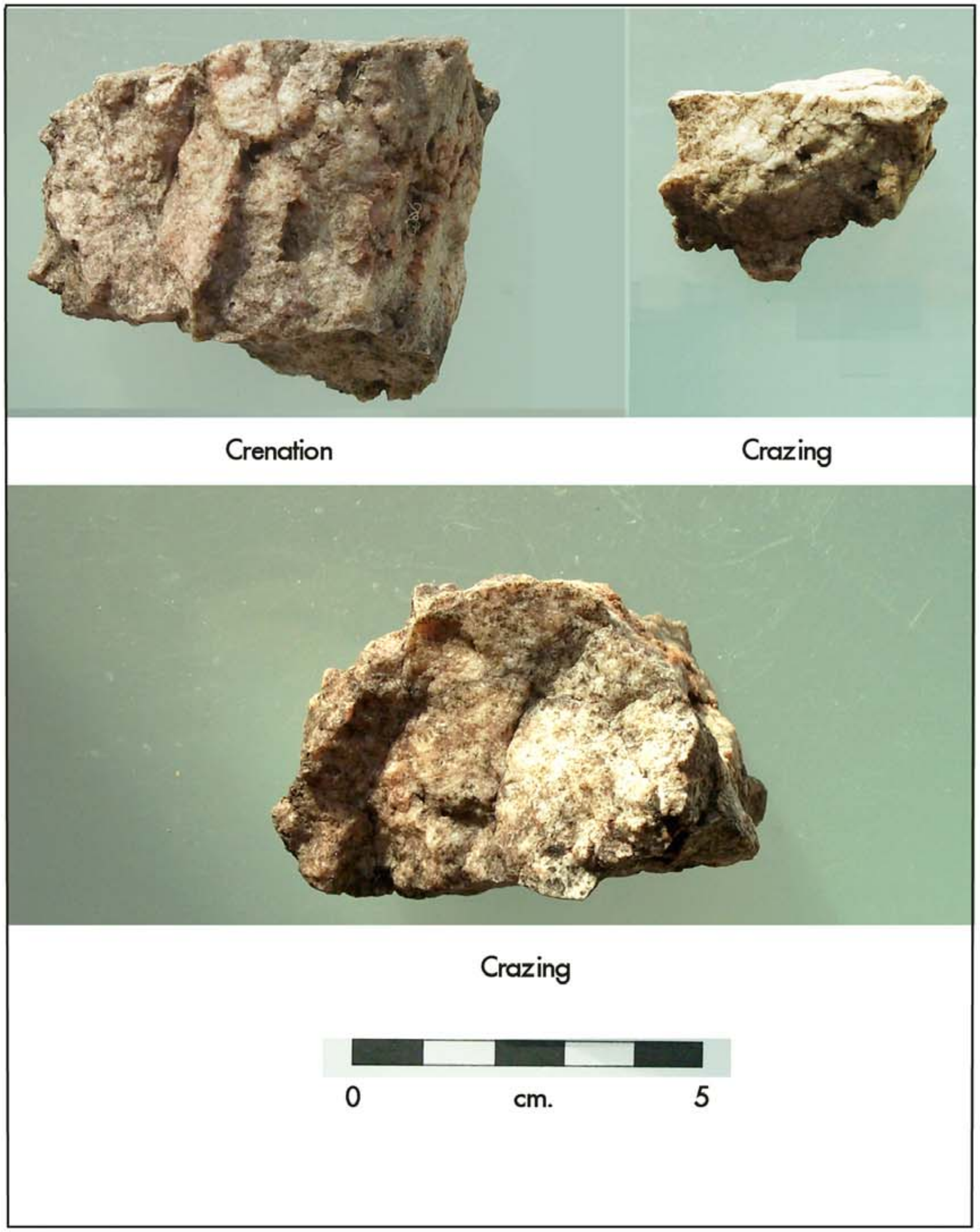


Figure 4.2. Thermal shock.

Unfortunately, the various causes of step fracture appear identical in the archaeological record. Although problematic, flake breakage is an important characteristic consideration for a debitage analysis.

Breakage was very common in all levels of Below Forks. Table 4.8 presents a summary of the breakage of flakes present in Below Forks. Breakage was analyzed for all flakes longer than one centimetre. The chart includes a distinction between all proximal portions, and only proximal portions. There were many examples of flakes that were broken in multiple locations. For the total counts of flakes the 'only proximal' and 'only distal' values were used to avoid the double counting of multiply broken flake fragments.

Breakage over time appeared very constant, with slightly more breakage occurring in the middle occupation (8%). Proximal portions were the most abundant type of flake portion, a pattern suggestive of step fractures that occurred during detachment from cores or objective pieces rather than post detachment taphonomic processes of trampling and excavation strategy. The split flakes were suggestive of bipolar techniques and hard hammer reduction. Unfortunately only 20% of all flakes were complete, a problem that reduced the identifiable flake types.

Table 4.8. Breakage summary for items greater than one centimetre by frequency.

Level	Complete	All Prx	Only Prx	Med	All Dst	Only Dst	Rb	Lb	Rs	Ls	Total *
Upper	49	113	82	20	24	20	16	17	34	32	270
Level 3	7	37	23	2	7	4	8	8	9	3	64
Middle	27	108	75	24	17	17	15	18	21	27	224
Level 7	43	118	80	21	22	22	12	14	21	30	243
Lower ~	552	1270	884	236	278	247	145	155	305	281	2805

~ lower includes microdebitage analysis * totals using only prx/dst count

Table 4.9. Breakage summary for items greater than one centimetre by percentage.

Level	Complete	All Prx	Only Prx	Med	All Dst	Only Dst	Rb	Lb	Lat Break	Rs	Ls	Split	Total*
Upper	18%	42%	30%	7%	9%	7%	6%	6%	12%	13%	12%	24%	270
Level 3	11%	58%	36%	3%	11%	6%	13%	13%	25%	14%	5%	19%	64
Middle	12%	48%	33%	11%	8%	8%	7%	8%	15%	9%	12%	21%	224
Level 7	18%	49%	33%	9%	9%	9%	5%	6%	11%	9%	12%	21%	243
Lower ~	20%	45%	32%	8%	10%	9%	5%	6%	11%	11%	10%	21%	2805

~ lower includes microdebitage analysis * totals using only prx/dst count

A transformation of the breakage analysis is the Sullivan and Rosen (1985) technique. Appendix 13 presents the results of a Sullivan and Rosen analysis of Below Forks debitage. The only significant interpretation from this analysis is that breakage was very common at Below Forks. The abundance of breakage was difficult to explain, especially when compared to a similar analysis of the Rustad site (Michael Michlovic, personal communication November 6, 2002). It related to a likely combination of the following processes:

1. *The nature of material type*. Swan River chert often step fractured. Below Forks had a very large proportion of breakage in the assemblage when compared to the Rustad Quarry site.

2. *Thermal alteration*, increased brittleness and the necessity for prepared platforms.

3. *Bipolar technology*.

4. *Trampling.*

5. *Excavation bias*, specifically the use of a rubber mallet to aid in screening. Importantly the upper components were not pounded through the screen. This only occurred to sediment from the lower occupation.

In all, there was an usually large amount of flake breakage in all the Below Forks occupations.

4. 9 Flake Terminations.

The terminations of the distal margins of each flake was analyzed to identify patterns in lithic technology. Tables 4.10 and 4.11 summarizes the proportion of flake termination in the Below Forks assemblage. Step fractures were the most common through all occupations, with feather next at 26-30%, hinge at 3-5%, crushing at 3-4%, outrepassé at 0-2%, while12-14% was indeterminate. The proportions of flake terminations did not significantly change over time. Hinge and crushed terminations were infrequent, while outrépassé was rare. Flake terminations indicated a great amount of breakage. The SRC appeared to have step fractured. Feather, hinge terminations occurred somewhat uncommonly. Outrépassé occurred very rarely in the assemblage and was fortuitous rather than intentional.

Table 4.10. Flake terminations by frequency.

Occupation	All	Feather	Hinge	Outrepassé	Crushed	Step	Indet
Upper	294	89	13	6	13	139	34
Level 3	71	17	2	0	3	40	9
Middle	245	58	10	1	8	134	34
Level 7	271	83	7	2	4	139	36
Lower	2301	605	114	23	62	1139	302

Table 4.11. Flake terminations by weight.

Occupation	Feather	Hinge	Outrepassé	Crushed	Step	Indet
Upper	30%	4%	2%	4%	47%	12%
Level 3	24%	3%	0%	4%	56%	13%
Middle	24%	4%	0%	3%	55%	14%
Level 7	31%	3%	1%	1%	51%	13%
Lower	27%	5%	1%	3%	51%	13%

4.10 Flake Types.

Flakes were placed into a typology based on the attribute analysis. The flake types include decortication, core-reduction, bipolar, shaping, bifacial reduction, and unifacial reduction flakes. Examples of each flake type are provided in the photographs presented in Appendix 14. The definitions of these flake types are as follows:

Primary decortication flakes: are flakes with cortex present on 100% of the dorsal surface. These flakes represent the initial stage of flake removal from the core. Of note were that all of the platforms were completely covered with cortex, and lacked any platform preparation whatsoever.

Secondary decortication flakes: are flakes with cortex present on 50 to 99% of the dorsal surface.

Tertiary decortication flakes: are flakes with cortex present on 1 to 50 % of the dorsal surface.

Core reduction flakes: generally have a complex exterior surface composed of a variety of flake scars, and are relatively large and thick. These flakes represent the reduction of cores into useful flake blanks. Since these flakes were discarded, they represent unusable flake blanks.

Bipolar flakes: are flakes with crushing on the platform and distal margin, a split bulb of force. Generally, a flat ventral surface is observable on this flake type (Low 1996; Silva 1997:35). These flakes were produced from reduction of a core between a hammerstone and an anvil. The bipolar flakes illustrated in Appendix 15.4 and 15.5 indicate that the bipolar technique was a common method to remove cortex from cores and produce large flake blanks.

Shaping flakes: have a strong linear dorsal ridge (arris) that guided the percussion force (Kooyman 2000:176). Metrically, shaping flakes always have greater length than width. Shaping flakes helped form and thin flake blanks into performs.

Bifacial reduction flakes: are relatively small flakes with a complex dorsal surface of flake scars, and frequently have a complex platform of multiple flake scars and additional platform preparations (Crabtree 1972:74-75; Kooyman 2000:170). These flakes represent tool thinning and later stages of tool forming. Bifacial reduction flakes were separated from unifacial reduction flakes based on the nature of platform flake scars (unifacial reduction flakes have fewer flake scars on the platform surface).

Unifacial reduction flakes: are relatively small flakes with a distinct curvature along the longitudinal axis (Andrefsky 1998:120-121). Unifacial reduction flake have flat platform surfaces, while bifacial reduction flakes often have rounded and more complex surface micro-topography. On the whole, bifacial and unifacial reduction flakes were separated on the basis of platform morphology and flake curvature. Unifacial reduction flakes were removed for the manufacture of unifacial working edges.

A great diversity of flake types were recovered from the Below Forks site. Tables 4.12 and 4.13 summarize the flake types identified for each occupation. In the upper occupation about 20 % less bifacial reduction occurred, and more decortication and shaping flakes were present than in the lower occupation. More secondary decortication occurred in the middle occupation. In this component less tertiary decortication and shaping was evident. The lower occupation had a greater number of all flake types, with significant quantities of decortication, shaping and bifacial reduction flakes. Core reduction, bipolar and unifacial reduction flakes were present. The number of pressure flakes in the site was difficult to assess. Most pressure flakes have lengths below one centimetre, commonly with a maximum length around four millimeters. The complete pressure flakes identified in the debitage analysis were unusually large, where the analysis caught the largest of the pressure flake size range. Pressure flakes were abundant in the lower occupation, and were common in the upper occupation. Most of the items between two and five millimetres were pressure flakes. In the five to ten millimetre size range roughly half of the debitage were pressure flakes, the other half were percussion flake fragments. On the whole, a wide variety of flake types were present in all occupations. A wide range of reduction activities occurred: decortication through both freehand and bipolar techniques, blank production, tool shaping and bifacial forming. Some unifacial reduction was identified, as was some pressure thinning. The debitage documents tool manufacture from initial core reduction through to tool finishing.

Table 4.12. Frequency of flake types by occupation.

	Decortication										
Occupation	Primary	Secondary	Tertiary	Bipolar	Core-Reduc.	Shaping	Bi-Reduc.	Uni-Reduc.	Pressure	Indet.	Total
Upper	0	6	6	4	3	20	8	0	0	2	49
Level 3	0	1	1	0	0	2	4	0	0	0	8
Middle	0	6	1	1	2	8	10	0	0	0	28
Level 7	1	1	4	2	2	23	12	0	0	1	46
Lower	8	43	50	33	13	184	187	3	12	7	540

Table 4.13. Percentage of flake types by occupation.

	Decortication										
Occupation	Primary	Secondary	Tertiary	Total	Bipolar	Core-Reduc.	Shaping	Bi-Reduc.	Uni-Reduc.	Pressure	Indet.
Upper	0%	12%	12%	24%	8%	6%	41%	16%	0%	0%	4%
Level 3	0%	13%	13%	25%	0%	0%	25%	50%	0%	0%	0%
Middle	0%	21%	4%	25%	4%	7%	29%	36%	0%	0%	0%
Level 7	2%	2%	9%	13%	4%	4%	50%	26%	0%	0%	2%
Lower	1%	8%	9%	19%	6%	2%	34%	35%	1%	2%	1%

4.11 Metric Analysis.

A metric analysis of each flake type was conducted to identify the relative stages of manufacture and their sequence. From excavations the following reduction pattern was hypothesized. Cores were reduced, first through cortex removal and then through flake blank production with freehand hard hammer techniques. Bipolar reduction was employed to create large and consistent flakes, partly for use as flake blanks. Useful flakes were roughed out with shaping flakes, then tool forming proceeded with bifacial and unifacial reduction. Tool preforms were finished with pressure flaking. This model of the reduction stage was tested with the metric analysis. The assumption was that larger flakes are situated earlier in the stage of reduction than smaller flakes. Appendix 16 provides the descriptive statistics from the metric analysis of flake types for each occupation. The following Figures, 4.3 to 4.5, were based on maximum flake length, although the same patterns are indicated on all the metric categories. The graphs indicate that there were no metric boundaries between flake types, instead lithic reduction forms a metrical continuum. The metric analysis of flake types was also conducted to identify patterns in platform size to aid in the interpretations of proximal flake portions. The results were unusable for that purpose, as the flake types blended together metrically.

The upper occupation, as illustrated on Figure 4.3, identified great metric variation for flake types. The sequence of reduction presented was: decortication and bipolar occurring at the same stage, then core-reduction and tool shaping, and finishing with bifacial reduction.

A different pattern of reduction was observed in the middle occupation (Figure 4.4). The large size of the core reduction flakes is problematic; ideally this represents flake blank production. Bipolar reduction flakes were larger, and thus earlier than freehand decortication. In turn, shaping occurred before bifacial reduction. The small sample size of this occupation does not allow for strong interpretation of reduction stages.

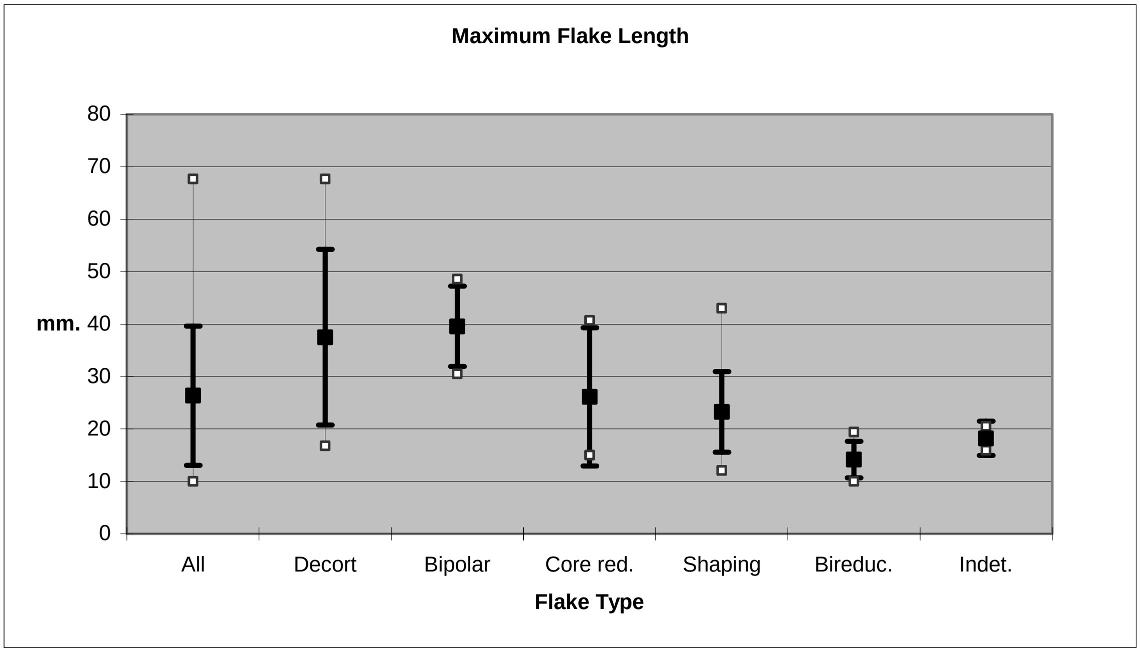


Figure 4.3. Metric analysis of complete flakes from the upper occupation.

The lowest occupation reduction pattern is depicted on Figure 4.5. Bipolar reduction occurred first, producing large flakes. Decortication flakes removed with bipolar techniques are a manifestation of this early stage reduction. Freehand decortication then occurred, removing cortex for flake blanks, followed with core reduction and shaping to form the blanks into tool preforms. Bifacial reduction thinned, while pressure flakes finished the tools. Thus the metric analysis of flake types was successful in identifying the general stages of reduction and the notable importance of bipolar technology.

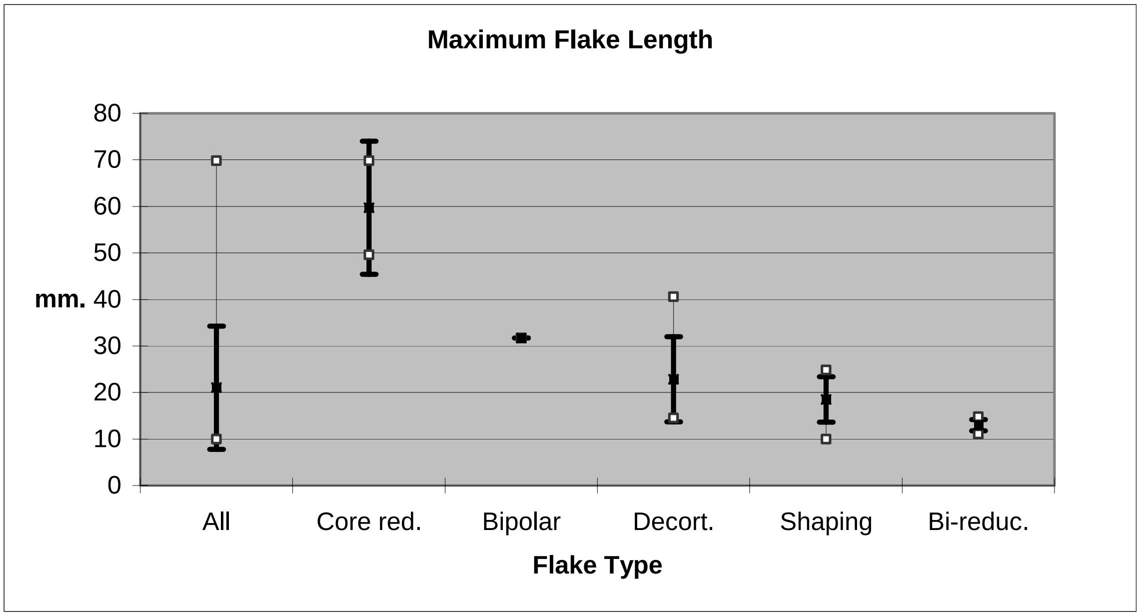


Figure 4.4. Metric analysis of complete flakes from the middle occupation.

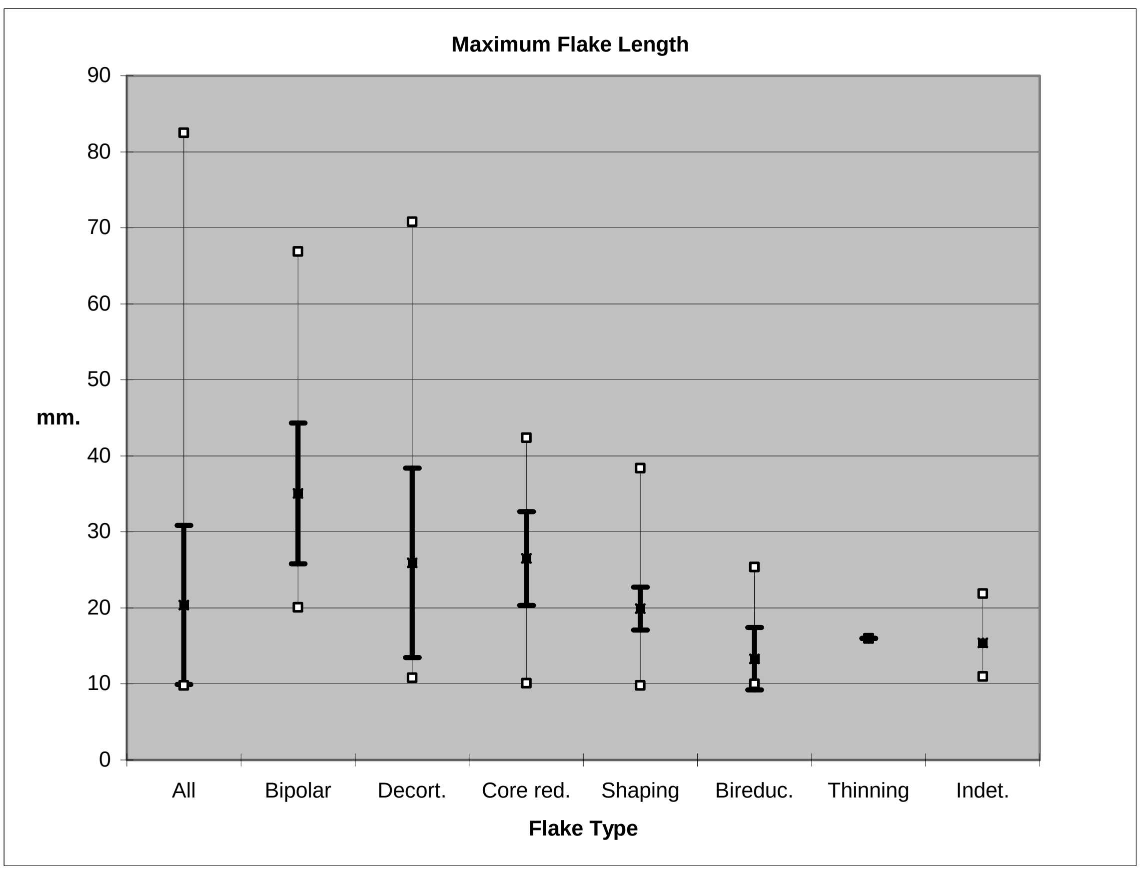


Figure 4.5. Metric analysis of complete flakes from the lower occupation.

4.12 Platform Shape.

Platform shape was analyzed with the aim that the attribute could identify flake type or reduction stage for proximal flake portions. Variations of the platform shape existed between percussion type, material and flake type, but on the whole these variations were slight. Platform shape data are provided in Appendix 17. Discoidal, oval and triangular forms account for 90% of all platform shapes. Definitive patterns of flake types were absent; unfortunately platform shapes are not specific to flake type. Of note is that indeterminate platform shapes were always caused from extensive crushing and collapsing of the platform. While rare, collapsed platform shapes occurred in all reduction stages. After extensive effort, it is unwise to record platform shape since the attribute is not indicative of reduction stage, detachment technique or technological variation.

4.13 Platform Preparation.

In tandem, the termination, breakage and thermal alteration indicated that SRC was a difficult material that needed extensive preparation for intended reduction. The pattern indicated that well thought out attempts to control the material had occurred. Unfortunately, step fracture was the common outcome of these efforts. The preparation of a platform was a means for a knapper to better control lithic reduction. Two methods of platform preparation were common at Below Forks: platform grinding and platform flaking. Tables 4.14 and 4.15 document the nature of platform preparation by occupation, percussor type and flake type. Platform crushing was not so much a preparation, but more of an effect of direct percussion with a hammerstone. Crushing left a characteristic circular ring crack and impact scar often located on the centre of the interior platform edge (Cotterell and Kamminga 1987). Such crushing was more common on hard hammer flakes (40%) then soft hammer (9%). Of note was that 73 % of the bipolar flakes exhibited crushing. This crushing constituted a defining feature of bipolar reduction. Platform grinding occurred on 48% of all flakes, on 45% of hard hammer flakes and 52% of soft hammer flakes. Bipolar flakes were not ground as much as all other flake types (about 25 % less). Platform grinding occurred on about one half of all flakes regardless of percussor type. Platform flaking occurred on just over half (55%) of all flakes, on 46% of hard hammer flakes, and 68% of soft hammer flakes.

Thus, platform flaking was slightly more common on soft hammer flakes than hard hammer. Platform grinding often occurred on the exterior platform edge, while platform flaking often occurred on the surface. To some degree platform flaking was increasingly common on later reduction stages, as indicated on Table 4.14.

Table 4.14. Platform flaking relative to flake type.

Flake Type	Platform Flaking
Bipolar	24%
Core Reduction	33%
Decortication	45%
Shaping	62%
Bifacial Reduction	70%

On the whole, platform preparation was very common for all flake types, 86%. The hypothesis that platform preparation increased as items became smaller was incorrect. Platform preparations were common on all flake types. The *nature* of platform preparation did change, the rate of grinding stayed constant, while platform flaking increased for later reduction stages.

Table 4.15. Platform preparation for all complete flakes by occupation.

			Preparations				Platform Flake Scars				
Level	All	Cortex	Crushing present	Grinding Present	Flaking Present	Lip Present	0 flake	1 flake	2 flakes	3 flakes	indet
Upper	214	18	36	128	100	48	3	40	80	20	71
L3	49	2	10	35	27	10	0	10	24	3	12
Middle	157	5	38	110	94	35	2	20	80	14	41
L7	175	11	36	116	85	34	4	36	73	12	50
Lower	1663	89	355	1096	894	375	31	278	720	174	460
Total	2258	125	475	1485	1200	502	40	384	977	223	634

			Preparations				Platform Flake Scars				
Level	All	Cortex	Crushing present	Grinding Present	Flaking Present	Lip Present	0 flake	1 flake	2 flakes	3 flakes	indet
Upper	214	8%	17%	60%	47%	22%	1%	19%	37%	9%	33%
L3	49	4%	20%	71%	55%	20%	0%	20%	49%	6%	24%
Middle	157	3%	24%	70%	60%	22%	1%	13%	51%	9%	26%
L7	175	6%	21%	66%	49%	19%	2%	21%	42%	7%	29%
Lower	1663	5%	21%	66%	54%	23%	2%	17%	43%	10%	28%
Total		6%	21%	66%	53%	22%	2%	17%	43%	10%	28%

Table 4.16. Platform preparation for all soft hammer flakes.

	Soft Hammer							Total
Flake Type	Bi - Reduc.	Shaping	Decort.	Other	Indet.	Uni- Reduc.	Thinning	Soft Hammer
All Flakes	220	86	16	1	4	5	1	333
No Preparation	6%	15%	19%	100%	25%	40%	100%	11%
Prepared	94%	85%	81%	0%	75%	60%	0%	89%
Crushing	10%	7%	0%	0%	25%	20%	0%	9%
Grinding	52%	52%	56%	0%	50%	40%	0%	52%
Flaking	70%	70%	56%	0%	50%	40%	0%	68%
Cortex Present	0%	0%	6%	0%	0%	0%	0%	0%
O Flake Scars	0%	0%	6%	0%	0%	0%	0%	0%
1 Flake Scar	15%	29%	38%	100%	50%	40%	100%	21%
2 Flake Scars	46%	57%	56%	0%	25%	20%	0%	49%
3 Flake Scars	23%	13%	0%	0%	25%	20%	0%	19%
Indet. Flake Scars	0%	1%	0%	0%	0%	0%	0%	1%

Table 4.17. Platform preparation for all hard hammer flakes

	Hard Hammer					Total
Flake Type	Decort.	Bipolar	Indet.	Core Redu.	Shaping	Hard Hammer
All Flakes (frequency)	85	33	3	12	98	231
No Preparation	16%	9%	33%	0%	10%	12%
Prepared	84%	91%	67%	100%	90%	88%
Crushing	35%	73%	33%	50%	32%	40%
Grinding	44%	24%	67%	67%	51%	45%
Flaking	45%	24%	0%	33%	56%	46%
Cortex Present	24%	12%	0%	0%	0%	10%
O Flake Scars	16%	12%	0%	0%	0%	8%
1 Flake Scar	34%	61%	100%	42%	42%	42%
2 Flake Scars	42%	18%	0%	25%	48%	40%
3 Flake Scars	2%	6%	0%	8%	8%	6%
Indet. Flake Scars	5%	3%	0%	25%	2%	4%

Table 4.18. Platform preparations at Below Forks by complete flake type.

										Totals
Flake Type	Decort.	Bipolar	Core-Reduc.	Shaping	Uni-Reduc.	Thinning	Bi-Reduc	Other	Indet.	All
All Flakes (frequency)	101	33	12	184	5	1	224	1	7	567
No Preparation	17%	9%	0%	13%	40%	100%	6%	100%	29%	14%
Prepared	83%	91%	100%	88%	60%	0%	94%	0%	71%	86%
Crushing	30%	73%	50%	20%	20%	0%	10%	0%	29%	29%
Grinding	46%	24%	67%	52%	40%	0%	52%	0%	57%	48%
Flaking	47%	24%	33%	62%	40%	0%	70%	0%	28%	52%
Cortex Present	21%	12%	0%	0%	0%	0%	0%	0%	0%	7%
O Flake Scars	15%	12%	0%	0%	0%	0%	0%	0%	0%	5%
1 Flake Scar	35%	61%	42%	36%	40%	100%	15%	100%	71%	39%
2 Flake Scars	45%	18%	25%	52%	20%	0%	46%	0%	14%	44%
3 Flake Scars	2%	6%	8%	10%	20%	0%	23%	0%	14%	8%
Indet. Flake Scars	4%	3%	25%	2%	0%	0%	0%	0%	0%	3%

4.14 The Magne (1985) Analysis.

The Below Forks lithic assemblage was analyzed with the Magne (1985) method to identify reduction stage. The Magne method groups debitage assemblages into reduction stages based on the number of platform flake scars (Magne 1985:128-129). Magne (1985:100) defined a flake as having a platform (platform remnant bearing) and shatter as not having a platform. Magne (1985:116-125) conducted some flint-knapping experiments to establish analytical categories to define technological variability. Early, middle and late reduction stage debitage were identified, with bifacial reduction and bipolar flakes included as a second category (Magne 1985:100-106). Magne's definition of early-middle-late debitage is: early flakes have zero to one platform flake scars, middle flakes have two flake scares, and late have three, or more, platform flake scars (Magne 1985:128-129). After analyzing many sites, statistical categories were identified for early/core reduction, middle/wide ranging reduction, and late/maintenance reduction stage site assemblages (Magne 1985:196-203). Table 4.19 presents a summary of Magne's source data for site reduction, excluding shatter. The *core reduction* sites had early stage reduction most abundant, followed by middle and late stage reduction respectively. Bipolar flakes are common, while cores are present. Activities at core reduction sites include the collection of raw material and initial flake blank production (Magne 1985:196-199). The *wide ranging reduction* sites indicate that early, middle and late stage debitage are distributed in even proportions, with much bifacial reduction and some bipolar reduction present (Magne 1985:200). There appears to be much diversity in the assemblage (Magne 1985:200). The complete manufacture sequence of tools is represented at wide ranging reduction sites (Magne 1985:201). *Maintenance* sites have few flakes and little to no bipolar flakes or cores (Magne 1985:200). Generally more middle and late flakes are present than early debitage, but the ratios are not all that dramatic. Activities at maintenance sites include the resharpening and retooling of imported tools (Magne 1985:201). These sites frequently express evidence of material conservation (Magne 1985:201). Of importance is that Magne analyzed the debitage assemblage as a whole. Magne also identified mutually exclusive definitions for his analysis. Accepting his methodological simplicity, it is worthwhile to analyze debitage variability at Below Forks with this method.

Table 4.19. Summary percentages from Magne's British Columbia archaeological sites (from data presented in Magne 1985:162-163).

Site Type	Early	Middle	Late	Bi-red. Flakes	Bipolar Flakes	Bipolar Cores	Cores
Core Reduction (Early)	47%	24%	9%	5%	11%	3%	1%
Wide Ranging (Middle)	27%	25%	19%	15%	9%	4%	1%
Maintenance(Late)	17%	34%	35%	13%	0%	0%	0%

The Below Forks analysis could not be directly compared to Magne's results, as flakes and shatter were defined differently. Below Forks' shatter, medial, distal and non-orientable flake fragments are included in Magne's (1985:100) definition of shatter, while the site's complete, proximal and split flake fragments fall into the umbrella of Magne's (1985:100) definition of platform remnant bearing flakes. For comparisons to Magne, shatter was excluded. Table 4.20 presents the percentages of Below Forks debitage on a modified Magne analysis. When compared to Magne's site types, all the occupations at Below Forks indicate a wide ranging reduction strategy; a strategy indicating the complete process of tool manufacture.

Table 4.20. Percentages from Below Forks, with a modified Magne (1985) analysis.

Level	Early	Middle	Late	Bi-Red	Bipolar	Bipolar cores	Cores
Upper	25%	47%	12%	5%	2%	1%	9%
Level 3	23%	57%	7%	9%	0%	0%	5%
Middle	20%	58%	10%	7%	1%	1%	2%
Level 7	35%	46%	8%	5%	1%	1%	3%
Lower	31%	43%	11%	8%	2%	1%	4%
Subtotal	30%	45%	11%	8%	2%	1%	4%

The Magne (1985) form of analysis is of value, although the Below Forks data appeared somewhat different from his model of wide ranging reduction sites. Below Forks consistently has 25% more middle stage debitage, and 10 % less late stage debitage than Magne's (1985) model sites. The differences might relate to the culture group, raw material, thermal alteration, or most likely some variable not taken in to account. All told, the Magne analysis indicated a diverse reduction strategy for all levels.

4.15 The Wright (1980) Analysis.

The nature of lithic reduction was analyzed with the Wright (1980) method. This method is based on the relationship between platform preparation, platform lipping, and presence of cortex. Figure 4.6 identifies the relationship between these attributes and the type of reduction implied, following Wright (1980:51-52). Fortunately, the Wright method analyses assemblages as a whole, objectively groups debitage based on combinations of defined attributes (Wright 1980:50-51). Notably, the Wright method suffers since it uses the presence or absence of platform lipping, a most problematic debitage trait. Categories that define each reduction stage in the Wright method were *mutually exclusive*, an important consideration that should not be undervalued. In lithic, and specifically debitage research, mutually exclusive definitions are exceedingly rare (Steffen et al. 1998). On this merit, Wright (1980) presented a valid analysis method.

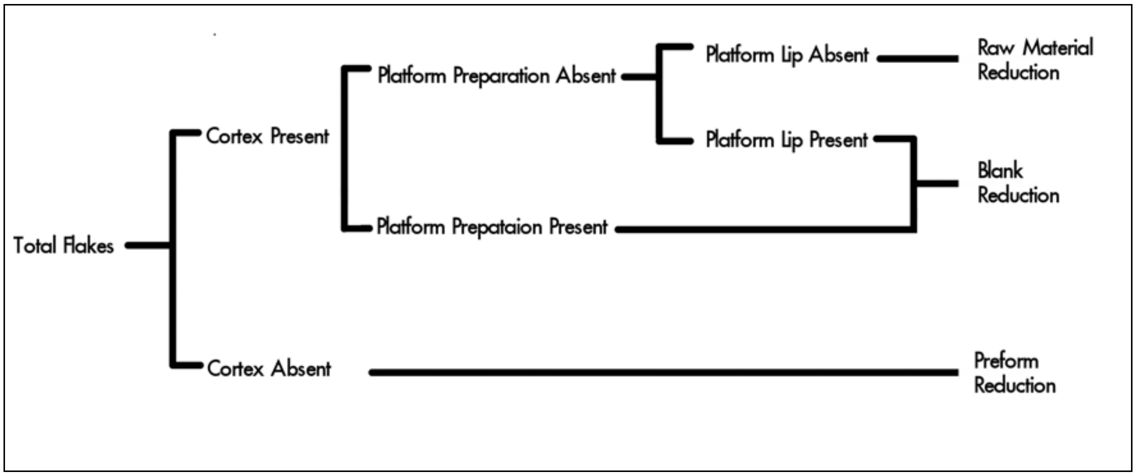


Figure 4.6. The Wright (1980) analysis flowchart.

Table 4.21 presents the expected values of reduction type for various site types. The chart is partly based on examples from Wright (1980:52), and my theoretical examples. Of note is the separation of quarry sites into primary and secondary types and the use of the Nebo Hill site as an example. Also included are two types of habitation sites: a habitation site where lithic materials are being conserved (essentially a habitation site in a lithic poor locale), and a refurbishing site (similar to Magne's [1985] maintenance site type).

Table 4.21. Wright (1980) analysis expectation for different site types.

Type of Site	Raw Material Reduction	Blank Reduction	Preform Reduction
Primary Quarry (23DL site)	90.0%	5.0%	4.0%
Secondary Quarry (Theoretical)	50.0%	40.0%	10.0%
Habitation (Nebo Hill site)	15.0%	15.0%	70.0%
Habitation-Conservation (Theoretical)	5.0%	5.0%	90.0%
Refurbishing (Theoretical)	0.0%	2.0%	98.0%

The proportion of reduction types of the various occupation of Below Forks is presented as Table 4.22. The ratios from all level are remarkably similar to Wright's Nebo Hills example. Thus, Below Forks fits a habitation site pattern and is not a primary quarry site. From the analysis, preform reduction is the most abundant reduction stage. Obviously, preform reduction is related to tool finishing. The presence of significant amounts of microdebitage supports this position. The Wright analysis showed that

Below Forks had a wide-ranging reduction strategy with preform reduction being most abundant.

Table 4.22. Wright (1980) analysis of Below Forks debitage.

Occupation	Raw Material Reduction	Blank Reduction	Preform Reduction
Upper	12.0%	12.0%	76.0%
Level 3	12.5%	12.5%	75.0%
Middle	14.3%	10.7%	75.0%
Level 7	14.3%	10.7%	75.0%
Lower	10.5%	8.5%	81.0%

4.16 Platform Lipping: Analysis and Discussions.

The nature of platform lipping observed on debitage is most problematic. Often platform lipping is used as a definitive indicator of soft hammer detachment techniques (Crabtree 1972:74-75), and has a relationship to a bending mode of force (Cotterell and Kamminga 1987; Tsirk 1979). Kooyman (2000:169) defined bending initiation as:

> the type of flake initiation that arises when there is a significant bending component in the force acting on the objective piece edge and so the fracture begins at a (relatively) great distance from the impact area; the resulting flake has a lip.

Kooyman (2000:23-24) also noted that:

> Soft Hammer percussion typically undergoes this type of fracture initiation [bending initiation]. Hertzian mechanics do not act in this type of initiation and no bulb of percussion results since there is no compressive stress field below the surface where the initiation actually occurs.

Hertzian initiation typically has a detachment near the platform edge, and a large bulb of percussion (Tsirk 1979). Bending initiation has a detachment farther away from the platform edge, and has a platform lip (Tsirk 1979). Kooyman overgeneralizes the distinction between hertzian and bending initiations. According to Kooyman, hertzian fracture produces bulbs of percussion, and therefore, only bending fracture produces platform lips. This point is carried from Cotterell and Kamminga (1987), they state:

> Bending initiations do not have a bulb of force, though the flake surface created during the transition from initiation to propagation can look superficially like a diffuse bulb and has been mistaken as such by

archaeologists. As Tsirk (1979:85) has pointed out, what Crabtree (1972:74) describes as a conchoidal flake showing a pronounced lip is a typical waisted bending flake (Cotterell and Kamminga 1987:690).

The Cotterell and Kamminga argument is based on a theoretical model of the physical behaviour of lithic fracture, and is not supported by experimental or archaeological data in the article. The acceptance of an untested model by archaeologists (eg. Kooyman 2000:22-24; Silva 1997: 8-10) is disconcerting.

The archaeological evidence at Below Forks runs counter to the purported model of the bending mode of force. There were numerous instances of large flakes with platform lips and *prominent* bulbs of percussion in the Below Forks assemblage, as well as smaller flakes with platform lips and weak bulbs of percussion. True bending initiations were also present, evident by flakes with platform lips and no bulbs of percussion. Table 4.23 identifies the presence or absence of platform lipping in relation to flakes with pronounced or diffuse bulbs of percussion. The presence of platform lipping did not nessecarily negate the presence of a bulb of percussion, nor negate the hertzian mode of force. In these situations, the hertzian cone just behaved differently. From the debitage analysis there was a complex relationship between platform lipping, intiation type, and bending and/or hertzian modes of force.

Table 4.23. Platform lipping in relation to bulb of percussion (from complete SRC flakes of the lower occupation).

Pronounced Bulbs (n=207)	Frequency	Percent
Lipping Present	30	15%
Lipping Absent	177	85%
Diffuse Bulbs (n=264)	Frequency	Percent
Lipping Present	109	41%
Lipping Absent	155	59%
Total	Frequency	Percent
Lipping Present	138	30%
Lipping Absent	331	70%

4.17 Size Grade Analysis.

The size grade analysis was an aggregate analysis that measured the amount of material by size ratio. Ahler (1986,1989) presented the comprehensive method of size grade analysis. Steffen et al. (1998:138) noted that size grade analysis is a valid method as it is standardized, objective and easily replicable. The premise behind the method is that specific reduction patterns have a size grade signature. The following size grade was used, grade one (G1) consists of all debitage greater than twenty millimetres, grade two (G2) are items less than twenty millimetres and greater than ten millimetres, grade three (G3) represents items less than ten millimetres and greater than six millimetres, and grade four (G4) consists of items less than six millimetres. The size grade analysis was conducted on debitage from the lowest occupation, and summarized as Appendix 19.

Three patterns were apparent in the Below Forks data. First was an elevation in G2 and a very high G4 for Gronlid siltstone, chalcedony, and Red Willow Creek silicified sandstone. A middle to late stage of reduction of these materials was indicated. Tool forming and finishing of these materials is indicated by this type of size grade pattern. The second size grade pattern was an exponential decrease along lower size grades for SRC, quartz, basalt, quartzite, siltstone, and silicified wood. A wide ranging reduction is represented by this pattern. A third pattern was an exponential increase along lower size grades for Red River chert and silicified peat. These materials were reduced in late stage reduction, essentially for tool finishing.

The size grade analysis was a valid, objective method to identify basic reduction patterns. The analysis indicated that different materials were reduced in different strategies, and that most of the material at Below Forks was reduced in a wide ranging pattern, and is consistent with the Magne (1985) model. Some materials were reduced in an early stage reduction pattern and others in a late stage reduction pattern.

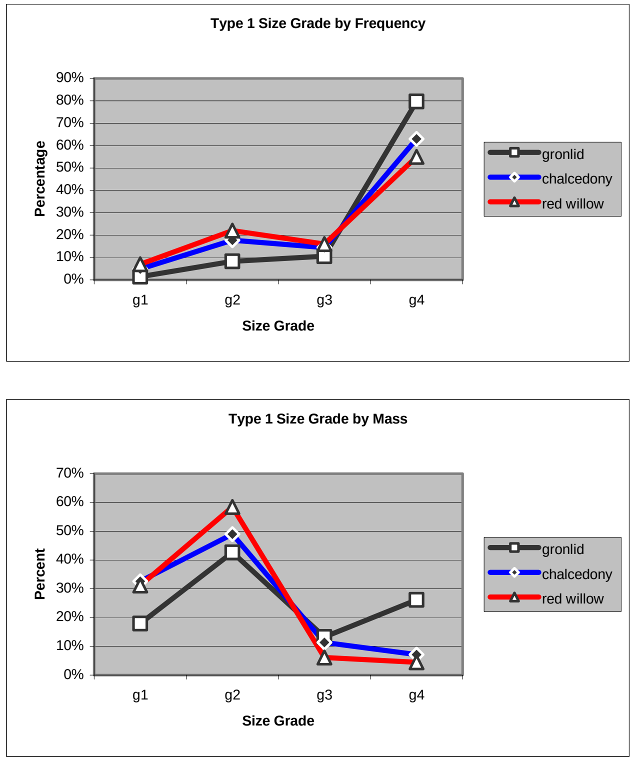


Figure 4.7. Type one size grade pattern: elevated G2 and G4

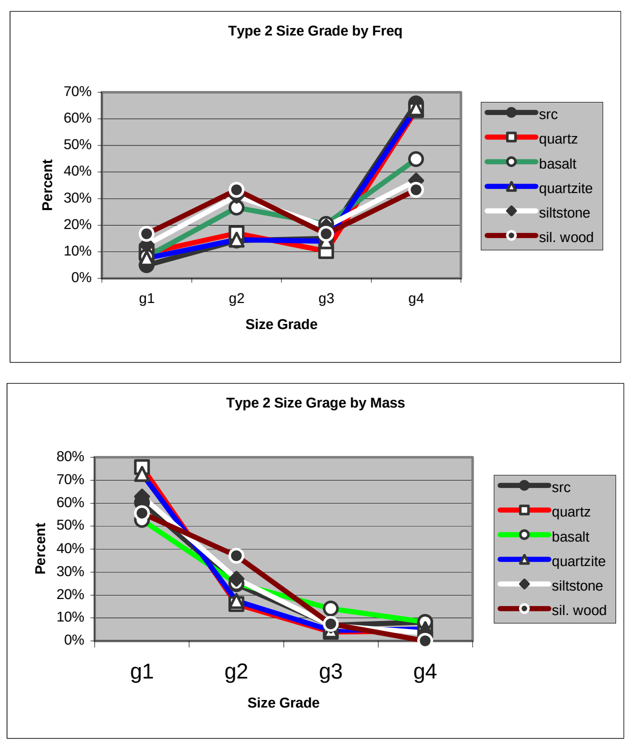
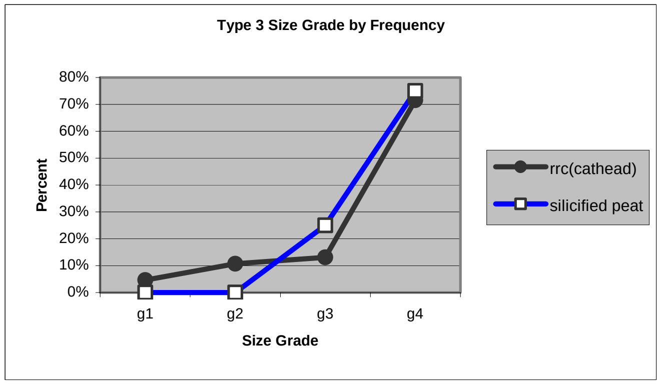


Figure 4.8. Type two size grade pattern: exponential decrease.



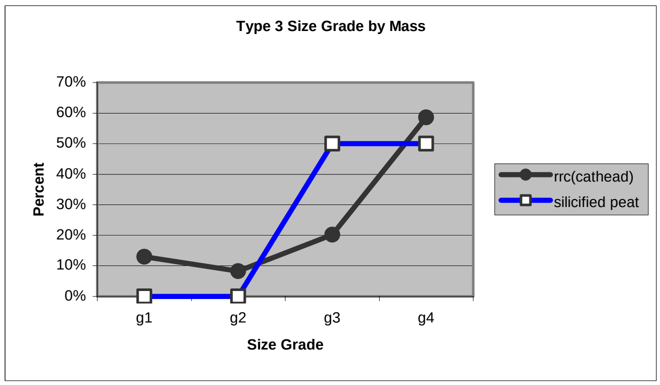


Figure 4.9. Type three size grade pattern: exponential increase.

4.18. Fractal Dimension.

4.18.1 The Fractal Dimension of Debitage.

The fractal dimension of lithic reduction is a quantitative measure of the fragmentation of debitage (Brown 2001). Fundamental to this form of analysis is the observation that stone fractures in a size-frequency pattern that obeys the power law (Turcotte 1986). In other words, the fracture of stone has a fractal behaviour. Archaeologically this means that debitage fractures in a size-frequency pattern that obeys the fractal/power law (Brown 2001:628-629). The first power-law relationship for debitage was presented by Stahle and Dunn (1982). Importantly, they presented a power-law equation in their article, but they did not identify it as a chaotic equation. Nor did they follow through to solve for the fractal dimension.

The power law is a mathematical equation that describes self-similarity of information without an inherent scale. From Brown (2001:620), the power law takes the form:

$$Y=aX^b, \qquad (4.1)$$

Where a is a constant, and b is a parameter of interest. A transformation of the equation from Brown (2001:620) is:

$$ln\, Y=ln\, a+b\, ln\, X. \qquad (4.2)$$

From Turcotte (1986:1921), the fragmentation of stone obeys the following power law relation:

$$N(>r)=r^{-D}, \qquad (4.3)$$

where N(>r) is the number of fragments with a size greater than r, r is the lowest size grade, and D is the fractal dimension. From Mandelbrot (1967:637), a transformation of the equation to solve for D is:

$$D=-\frac{ln(N(>r))}{ln(r)} \qquad (4.4)$$

Following Brown (2001:621-622), to identify the fractal dimension of an archaeological sample one must build a chart that indicates the size interval in millimeters, the lower bound (r), the frequency of debitage in each size interval, (N>r), and must solve for *ln* (r) and *ln* (N>r). This system follows a Sollberger distribution (Gunn et al. 1976). The lowest size grade and the frequency form a distribution, and the values of the size grade in millimeters forms the "r" of the equation (4.3). (N>r) is the cumulative frequency, or the total number of flakes above each size interval. This creates a chart in the form of Table 4.24. Then from the chart one conducts a linear regression for *ln*(r) as X values, and *ln*(N>r) as Y values (Brown 2001:621). The regression must be in the form:

$$Y=slopeX + intercept. \qquad (4.5)$$

The inverse of the slope of the regression of [*ln*(r) and *ln*(N>r)] is the fractal dimension of the assemblage (Brown 2001:621). R^2 is "the coefficient of determination, the statistic that measures the proportion of variation in the data explained by the regression" (Brown 2001:621) and must be included as an assessment of the regression. Table 4.25 presents the fractal dimension of Below Forks by occupation.

Table 4.24. Sollberger distribution chart for Below Forks debitage.

Upper Occupation					
Size Interval,	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	1	604	0.81093	6.403574
4.49 to 10	4.49	204	603	1.501853	6.401917
10 to 20	10	242	399	2.302585	5.988961
20 to 40	20	136	157	2.995732	5.056246
40 to 80	40	21	21	3.688879	3.044522
Level 3					
Size Interval,	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	4	143	0.81093	4.962845
4.49 to 10	4.49	29	139	1.501853	4.934474
10 to 20	10	78	110	2.302585	4.70048
20 to 40	20	29	32	2.995732	3.465736
40 to 80	40	2	3	3.688879	1.098612
Middle Occupation, Levels 4 to 6					
Size Interval,	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	11	605	0.81093	6.405228
4.49 to 10	4.49	191	594	1.501853	6.386879
10 to 20	10	277	403	2.302585	5.998937
20 to 40	20	113	126	2.995732	4.836282
40 to 80	40	13	13	3.688879	2.564949
Level 7					
Size Interval,	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	1	576	0.81093	6.356108
4.49 to 10	4.49	178	575	1.501853	6.35437
10 to 20	10	291	397	2.302585	5.983936
20 to 40	20	100	106	2.995732	4.663439
40 to 80	40	6	6	3.688879	1.791759
Lower Occupation, Levels 8 to 12					
Size Interval,	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	15858	24338	0.81093	10.09979
4.49 to 10	4.49	3968	8480	1.501853	9.045466
10 to 20	10	3357	4512	2.302585	8.414496
20 to 40	20	1099	1155	2.995732	7.051856
40 to 80	40	56	56	3.688879	4.025352
Microdebitage Analysis					
Size Interval,	Lower Bound (r)	Frequency	(N>r)	*Ln(r)*	*ln (N>r)*
1.15 to 2.25	1.13	2027	4519	0.122218	8.416046
2.25 to 4.49	2.25	1526	2492	0.81093	7.820841
4.49 to 10	4.49	686	966	1.501853	6.873164
10 to 20	10	220	280	2.302585	5.63479
20 to 40	20	58	60	2.995732	4.094345
40 to 80	40	2	2	3.688879	0.693147

Table 4.25. Regression for the fractal dimension of debitage at Below Forks.

Occupation	Regression Equation	Fractal Dimension	Coefficient of Determination
		D	R^2
Upper Occupation	y=-2.1838x+10.593	2.18	0.8799
Level 3	y=-1.8706x+8.4034	1.87	0.925
Middle Occupation	y=-2.2487x+10.646	2.25	0.9089
Level 7	y=-2.3462x+10.737	2.35	0.9225
Lower Occupation	y=-2.6476x+0.8803	2.65	0.8803
Microdebitage Analysis	y=-1.8632x+11.884	1.86	0.9117

Fortunately, Brown (2001:623) provided summaries of the fractal dimension of a wide variety of experimental research. He observed that the fractal dimension increased with later reduction stages, while early reduction stages had modest D values (Brown 2001:624). Cobble testing had a D value of 1.35 (Brown 2001:625), while expert bifacial thinning was 2.85 (Brown 2001:623). Brown stated that: "There is a natural and systematic relationship between fractal dimension and stage of reduction" (Brown 2001:624). Once understood, the method has an elegant simplicity.

For Below Forks, from the Table 4.25, the upper occupation described general early stage reduction, level 3 described early stage reduction, the middle occupation described early to middle stage reduction, level 7 described early to middle stage reduction, while the lower occupation described middle stage reduction. These interpretations should be taken with caution as more research and proper examples are needed to fully identify patterns of group behaviour on the fractal dimension of debitage. With that said, the fractal dimension of debitage is a good method to interpret reduction stage patterning and is a better method for comparisons of fragmentation patterns between sites, as the actual size of the size grade does not influence or skew the interpretation of the fractal dimension (Brown 2001:622).

4.18.2 Fractal Dimension of Flake Types.

Brown (2001:624) hypothesizes that the fractal dimension has a systematic relationship to reduction stage. I have tested this model by analyzing the fractal dimension of flake types. Later stage flake types should have a larger fractal dimension than earlier reduction stage materials. Tables 4.26 and 4.27, and Figure 4.10

summarize the Sollberger distribution and fractal dimension of various flakes types from the lower occupation. To avoid material type biases, only SRC flakes are included. As the R^2 was low for bipolar flakes, items with crushed termination were included to serve as a redundancy and check. As is apparent, fractal dimension increases with later stage flake types. From separate analyses, I can confirm the order of the relative stage of reduction. Bipolar reduction is the earliest stage, then decortication, shaping and bifacial reduction in sequence. Brown's hypothesis is correct: later stage reduction has a systematically larger fractal dimension than earlier stages.

4.18.3 Fractal Dimension and Thermal Alteration.

An additional application of Brown's fractal dimension analysis is an investigation of the nature of thermal alteration. The foundation of the fractal dimension method was Turcotte's (1986:1923) observation that rock fragmented with a fractal behaviour and that softer, more easily broken rocks have a lower fractal dimension than stronger rock. Since thermal alteration changes the physical properties of raw material, a change in fractal dimension is also expected. Table 4.28 and Figure 4.11 provide a summary of the fractal dimension of Swan River chert in natural and thermally altered forms from the lower occupation. Thermal alteration increases the fractal dimension of the material. Such an increase is only possible if the material becomes more stable physically, so that the rock fractures more homogeneously. This is only possible if there is an increase in microfractures. Leudtke (1992:96) hypothesized that: "the crack model, argues that heating increases the number of microflaws in chert and/or distributes them more evenly". The observation of an increase in fractal dimension of chert fragmentation from thermal alteration confirms the crack model.

Table 4.26. Sollberger distribution chart by flake type (lower occupation, SRC only).

Lower Occupation, Primary and Secondary Decortication					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln(r)*	*ln (N>r)*
10 to 15	10	6	42	2.3025851	3.7376696
15 to 20	15	9	36	2.7080502	3.5835189
20 to 30	20	17	27	2.9957323	3.2958369
30 to 40	30	5	10	3.4011974	2.3025851
40 to 50	40	3	5	3.6888795	1.6094379
>50	50	2	2	3.912023	0.6931472
Lower Occupation, Tertiary Decortication					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln(r)*	*ln (N>r)*
10 to 15	10	8	39	2.3025851	3.6635616
15 to 20	15	8	31	2.7080502	3.4339872
20 to 30	20	14	23	2.9957323	3.1354942
30 to 40	30	7	9	3.4011974	2.1972246
40 to 50	40	0	2	3.6888795	0.6931472
>50	50	2	2	3.912023	0.6931472
Lower Occupation, Bipolar					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln(r)*	*ln (N>r)*
10 to 15	10	0	27	2.3025851	3.2958369
15 to 20	15	1	27	2.7080502	3.2958369
20 to 30	20	6	26	2.9957323	3.2580965
30 to 40	30	13	20	3.4011974	2.9957323
40 to 50	40	5	7	3.6888795	1.9459101
>50	50	2	2	3.912023	0.6931472
Lower Occupation, Shaping					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln(r)*	*ln (N>r)*
10 to 15	10	44	168	2.3025851	5.123964
15 to 20	15	52	124	2.7080502	4.8202816
20 to 30	20	63	72	2.9957323	4.2766661
30 to 40	30	9	9	3.4011974	2.1972246
Lower Occupation, Bifacial Reduction					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln(r)*	*ln (N>r)*
6 to 10	6	14	168	1.7917595	5.123964
10 to 15	10	128	154	2.3025851	5.0369526
15 to 20	15	22	26	2.7080502	3.2580965
20 to 30	20	4	4	2.9957323	1.3862944
Lower Occupation, Crushed Terminations					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln(r)*	*ln (N>r)*
10 to 15	10	1	35	2.3025851	3.5553481
15 to 20	15	1	34	2.7080502	3.5263605
20 to 30	20	11	33	2.9957323	3.4965076
30 to 40	30	14	22	3.4011974	3.0910425
40 to 50	40	5	8	3.6888795	2.0794415
>50	50	3	3	3.912023	1.0986123

Table 4.27. The Fractal dimension of flake types from the lower occupation.

Flake Type	Regression Equation	Fractal Dimension	R-squared
		D	R^2
1° and 2° Decortication	y=-1.9048x+8.5715	1.90	0.9131
3° Decortication	y=-2.0873x+8.9154	2.09	0.9032
Bipolar	y=-1.4458x+7.161	1.45	0.6953
Shaping	y=-2.6143x+11.56	2.61	0.8445
Bifacial Reduction.	y=-3.0645x+11.206	3.06	0.8218
Crushed Terminations	y=-1.4342x+7.3514	1.43	0.7567

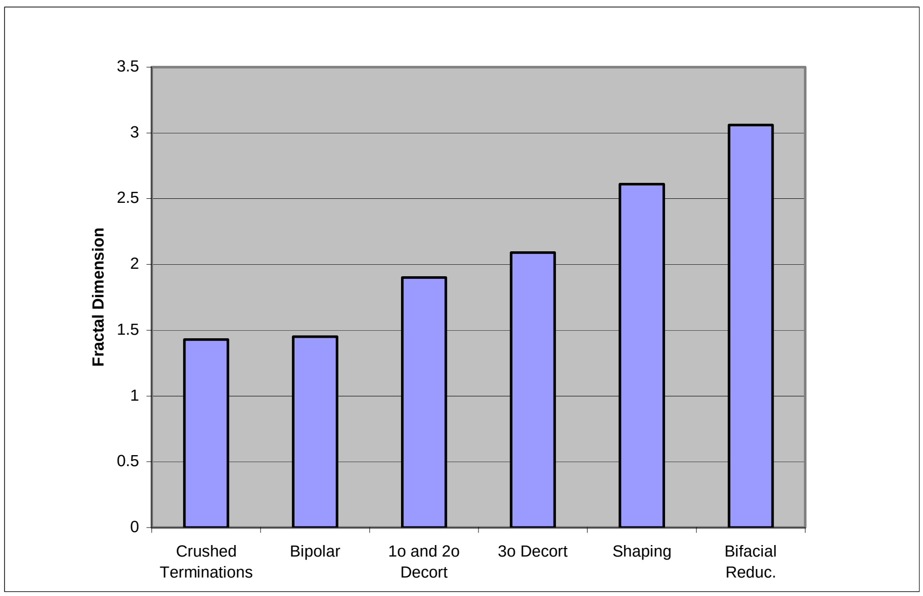


Figure 4.10. Fractal dimension of flake types of the lower occupation, SRC only.

Table 4.28. Sollberger distribution of lower occupation thermal alteration of SRC.

Thermal Alteration Present					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	11031	16845	0.810930216	9.73180916
4.49 to 10	4.49	2451	5814	1.501852702	8.66802408
10 to 20	10	2432	3363	2.302585093	8.12058871
20 to 40	20	847	931	2.995732274	6.83625928
40 to 80	40	82	84	3.688879454	4.4308168
>80	80	2	2	4.382026635	0.69314718
Thermal Alteration Maybe Present					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	99	241	0.810930216	5.48479693
4.49 to 10	4.49	22	142	1.501852702	4.95582706
10 to 20	10	88	120	2.302585093	4.78749174
20 to 40	20	30	32	2.995732274	3.4657359
40 to 80	40	2	2	3.688879454	0.69314718
Thermal Alteration Absent					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	2310	3442	0.810930216	8.14380798
4.49 to 10	4.49	600	1132	1.501852702	7.03174126
10 to 20	10	389	532	2.302585093	6.27664349
20 to 40	20	123	143	2.995732274	4.96284463
40 to 80	40	20	20	3.688879454	2.99573227
Total SRC					
Size Interval, mm.	Lower Bound (r)	Frequency	(N>r)	*ln*(r)	*ln* (N>r)
2.25 to 4.49	2.25	13440	20525	0.810930216	9.92939893
4.49 to 10	4.49	3073	7085	1.501852702	8.86573515
10 to 20	10	2909	4012	2.302585093	8.29704515
20 to 40	20	997	1103	2.995732274	7.00578902
40 to 80	40	104	106	3.688879454	4.66343909
>80	80	2	2	4.382026635	0.69314718

Table 4.29. Fractal dimension of thermal alteration of SRC from the lower occupation.

All SRC	Regression Equation	R^2	Fractal Dimension
Altered	y=-2.342x+12.535	0.8852	2.34
Maybe Altered	y=-1.5136x+7.2982	0.8096	1.51
Not Altered	y=-1.6984x+9.7286	0.9621	1.70
Total	y=-2.377x+12.789	0.8794	2.38

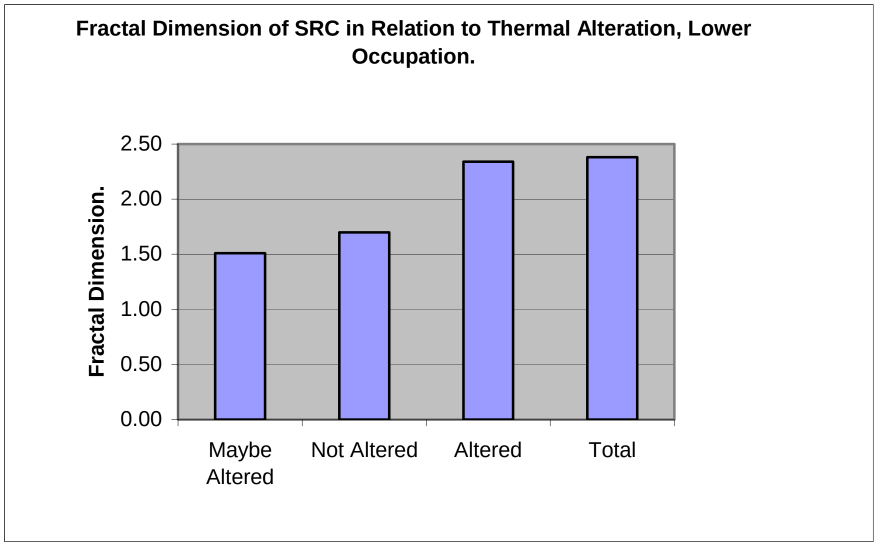


Figure 4.11. The fractal dimension of thermal alteration.

4.19 Flake Initiations and Minimum Number of Flakes.

Hiscock (2002) presented methods for the quantification of debitage that incorporated taphonomic processes and differential fragmentation into the counts. Key terms are NAS, the number of artifactual specimens, and MNF, the minimum number of flakes. The terms are synonymous with NISP and MNI of traditional faunal analysis (Lyman 1994). The quantification was based on differentiating flakes from shatter, complete flakes from broken, and specific flake portions of transverse section, proximal, medial, distal, and longitudinally split and broken portions, and non-orientable flake fragments. Hiscock (2002:254) provided a measure of flake initiation in the following equation.

$$FI=C+P+(LCS/2), \qquad (4.6)$$

Where C is the number of complete flakes, P is the number of proximal fragments, and LCS is the number of longitudinal fragments. Great care was necessary to set up Below Forks data for this equation. It was straight forward to isolate complete flakes from the debitage analysis. Separating proximal fragments from longitudinally split and broken flakes proved more difficult. Proximal portions were defined as items with a complete platform. Longitudinal sections were defined as split and longitudinally broken flakes with a complete transverse section and split proximal fragments (rs + ls

+rb+lb+prx:rs+prs:ls). The flake initiation method centres on the frequency of complete and broken platforms in an assemblage, and ignores distal and medial portions.

Hiscock (2002:254) presents a MNF equation that takes both flake initiation (platforms) and termination into account:

$$MNF=C+T+L, \qquad (4.7)$$

Where C is the frequency of complete flakes, T is the largest category of transverse fragments (proximal or distal portions, excluding longitudinally broken proximal and distal fragments). L is the count of longitudinal fragments in the following equation.

$$L=CL+BL, \qquad (4.8)$$

Where CL is the greater of left or right longitudinal fragments complete with fracture initiation and termination (ls,lb,rs,rb). BL is the largest of the following four longitudinal categories: right-proximal, left-proximal, right-distal, left-distal.

Therefore in expanded form:

	Complete Flakes		Transverse portion		Complete longitudinal portion		Broken longitudinal portion	
MNF =	C	+	T	+	CL	+	BL	(4.9)*
			Greater of 1) proximal portion without longitudinal breakage. [(all *prx*) - *prx:ls* - *prx:rs* -*prx:rb*- *prx:lb*] 2) distal portions without longitudinal breakage [(all *dst*) - *dst:lb* -*dst:rb*]		Greater of 1) left (*ls+lb*) 2) right (*rs+rb*)		Greater of 1)left-proximal (*prx:ls+prx:lb*) 2)right-proximal (*prx:rs+prx:rb*) 3)left-distal (*dst:lb*) 4)right-distal (*dst:rb*)	

* The notation was a shorthand of flake completion and breakage used in cataloguing. The format for combinations of breakage pattern follows:

Artifact = transverse portion: longitudinal split: longitudinal break. (4.10)

blank = a complete flake
prx = proximal portion
med = medial portion
dst = distal portion
rb = right broken fragment
lb = left broken fragment
rs = right split fragment
ls = left split fragment.

Artifact *prx:ls:rb* represented a proximal portion with a left split and a right break.
Artifact *ls* represents left split only, a complete transverse section with a left split.

Table 4.30. Minimum Number of Flakes

	Specimen Counts							Total Counts			
Level		Longitudinal			Transverse			NAS	FI Initations	MNF	Fragmentation Index
		CL									
	Complete	Left	Right	BL	Proximal	Medial	Distal		FI=C+P+(LCS/2)	MNF=C+T+L	NAS/MNF
Upper Occupation	49	32	34	19	82	20	20	404	182.5	185	2.18
Level 3	7	9	3	9	23	2	4	111	46	45	2.47
Middle Occupation	27	27	21	21	75	24	17	411	149	147	2.80
Level 7	43	30	21	21	80	21	22	394	166.5	166	2.37
Lower Occupation	535	275	299	193	819	189	214	4209	1799.5	1763	2.39
Microdebitage Analysis	17	6	6	8	65	47	33	258	91.5	91	2.84

Hiscock (2002) argues that FI (Flake initiation) quantities often underrepresented the real number of flakes. Table 4.30 presents the FI and MNF of the Below Forks occupations. The values of FI and MNF are nearly identical (the R^2 is 0.999989). The FI was slightly greater than the MNF values, a likely over-representation f FI due to definitions of proximal longitudinal fragments, and occasional errors in the data, such as counting twice proximal fragments that are both left and right split. The Below Forks MNF and FI values were remarkably similar because proximal fragments were more abundant than distal flake portions. The MNF method identifies distal portion overabundance; such abundance was not significant in the Below Forks assemblage. Instead, more proximal than distal portions were present. This related to two factors: first was the tendency of Swan River chert to step fracture on the core, and second, distal fragments were very difficult to correctly orient and were often catalogued as non-orientable flakes. The MNF method identified a greater intensity of lithic reduction in the lower occupation, including the abundance of proximal flake portions, and step termination. The MNF method also quantified fragmentation.

4.20 Testing Henry et al. (1976).

Metrical analysis of debitage is commonly undertaken to identify technological variation. One such attempt was presented in Henry et al. (1976). The authors argued that percussor type could be determined through metrical analysis of debitage, positing that the ratio between maximum flake thickness and weight provided mean values that separate hard hammer, soft hammer and pressure flakes (Henry et al. 1976). Essentially, size ranges of debitage identify hard hammer, soft hammer and pressure flakes. This was an ideal model for testing with data from Below Forks, since percussor type of flakes were identified by the independent means of a detailed attribute analysis. Figures 4.12 and 4.13 show the results of using a ratio of maximum thickness to weight for each flake.

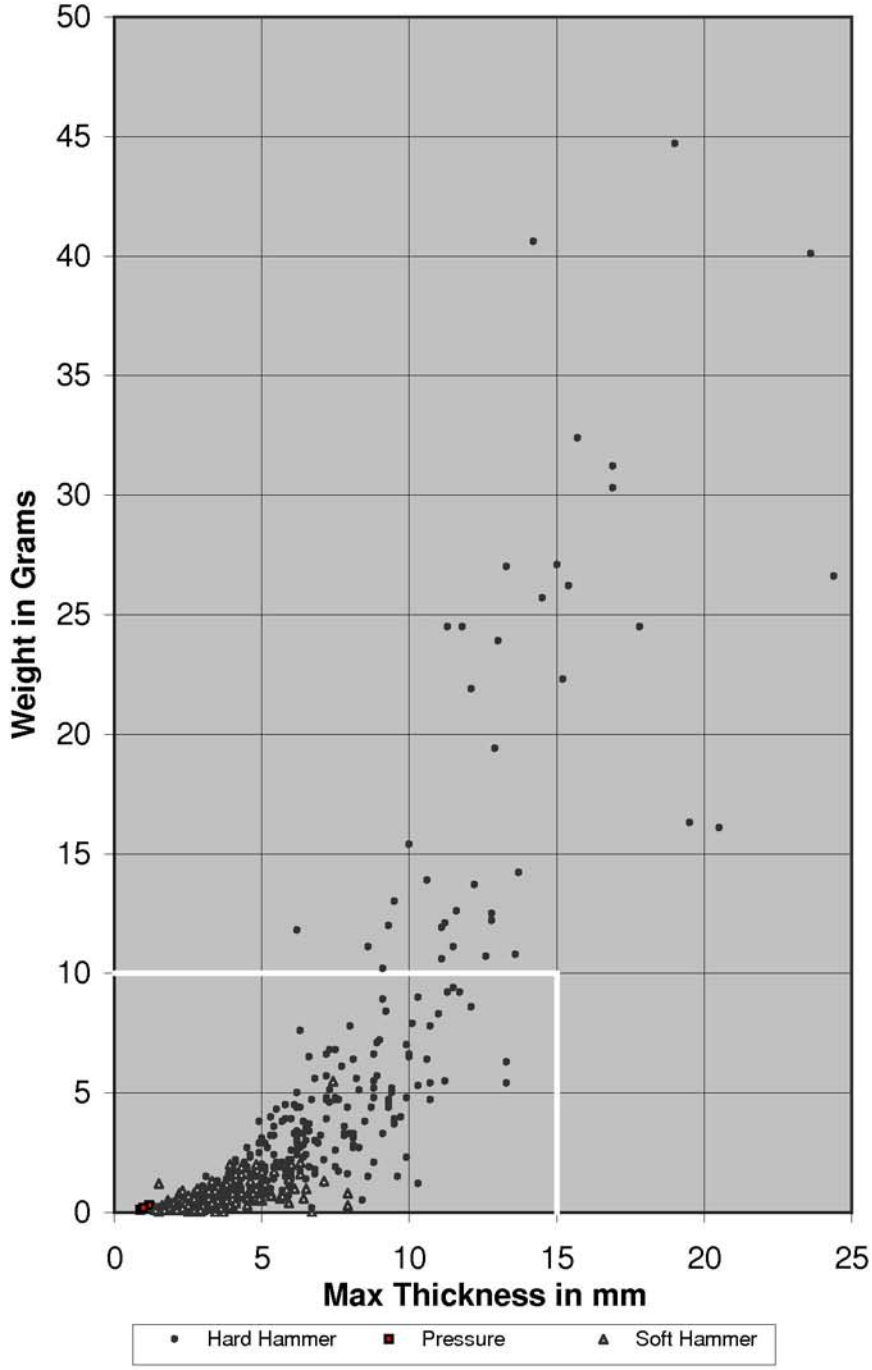


Figure 4.12. Ratio of maximum thickness to weight for hard hammer, soft hammer and pressure flakes.

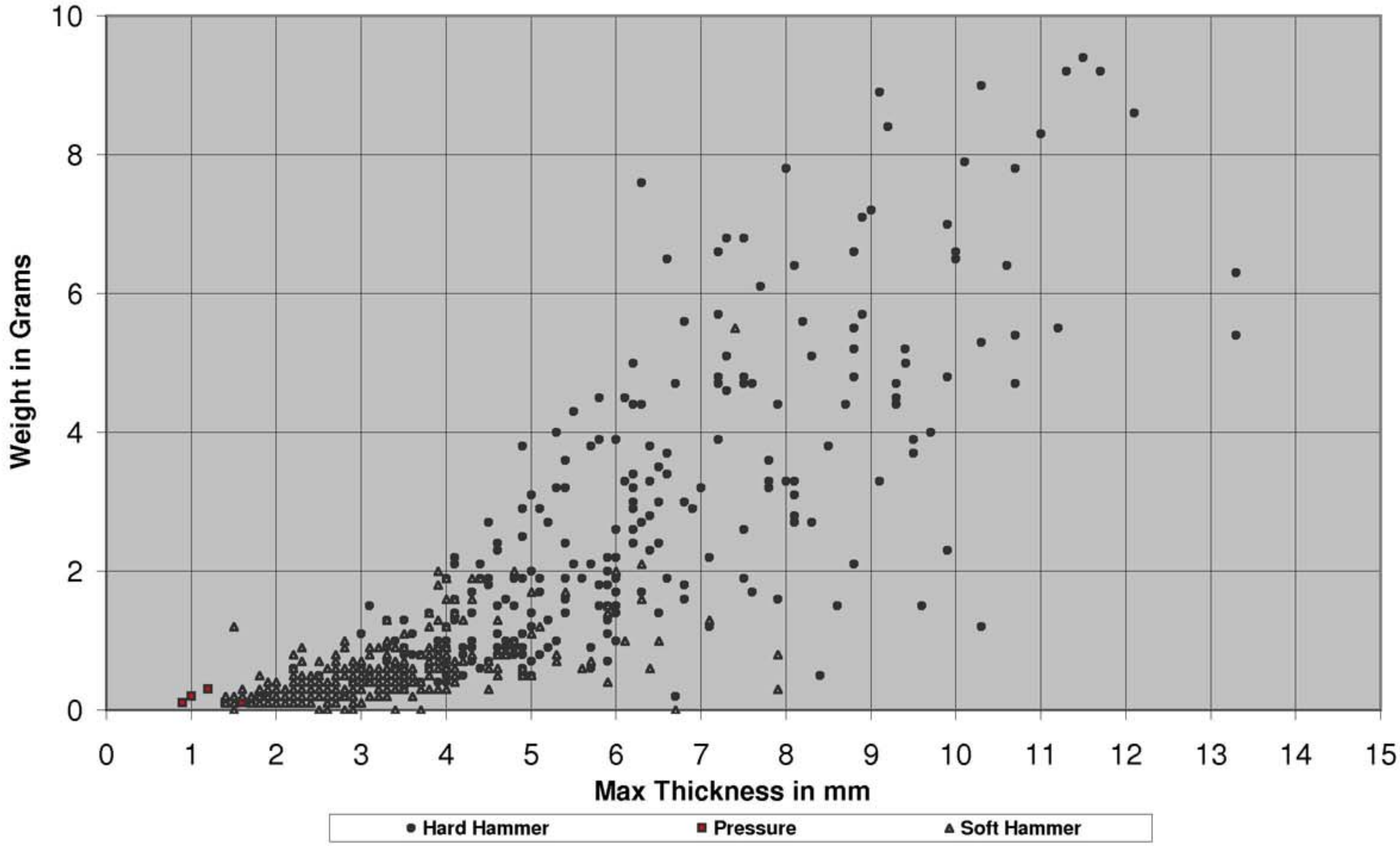


Figure 4.13. Detail of Figure 4.12.

It is apparent that the Henry model is partly correct, and partly mistaken. The reality of debitage variation is more complex than the presentation in Henry et al. (1976). By interpreting Below Forks data by their ratios, hard hammer flakes blended into soft hammer flakes, which in turn blended into pressure flakes. Core areas occurred on the scatter-plot for each percussor type, but the edges between these areas significantly blurred. In a similar situation Bordes accepted typologies that blend together by setting boundaries that arbitrarily remove areas of overlap to produce mutually exclusive categories (Bordes 1969:5-7). In this situation such a boundary was inappropriate. The use of the ratio between maximum thickness and weight was an inappropriate approach to identify percussor type.

4.21 Summary.

Chapter four presented a detailed debitage analysis and identified the nature of lithic technology present at the Below Forks site. Methodology was presented, mostly defining the various attributes of debitage analysis. Material type was analyzed, and a noticeable abundance of SRC was observed. Locally available materials represented 99% of all materials in the site, less than 1% was regionally available Red Willow Creek silicified sandstone. Exotic materials were present in trace amounts in the lower occupation. Thermal alteration was abundant at the site, and I note that SRC and Red River chert were thermally altered. Flake breakage was analyzed. This identified the unusual amount of step fracture present throughout the entire assemblage. A wide range of lithic flake types were represented at the site and indicate a process of tool manufacture from initial core reduction to tool finishing. Despite extensive efforts, tool resharpening was not recognized. Reduction technology indicated the importance of bipolar technology for flake-blank production. Platform shape is an unimportant flake attribute and should not be recorded. Platform preparations were common in all reduction stages. Platform grinding and platform flaking were important methods to control individual flake detachments. Only platform flaking increased for later stages of reduction. The Magne (1985) method and Ahler's (1986) size grade methods indicate a wide ranging reduction strategy, while a Wright (1980) analysis indicated the abundance of preform reduction that occurred at the site.

The relationship between platform lipping and initiation type is complex. The fractal dimension (Brown 2001) is a correct measure of reduction stage. This analysis illustrated the wide ranging reduction strategy at the site. It also confirms the crack model of thermal alteration. Flake initiation and the minimum number of flakes (Hiscock 2002) indicate the abundance of flake breakage and fragmentation. Finally, the Henry et al. (1976) metrical model is debunked as an inappropriate method to identify flake detachment techniques. Though this chapter relied heavily on technical methodology, the overall nature of the lithic technology present at the Below Forks sites was addressed.

"For example, what is an expedient tool versus a formal tool?
Is a simple utilized flake really that much more expedient than a uniface
or simple biface in the context of tool manufacture generally?
All three are pretty easy to make."
Magne (2001:28).

5. TOOL ANALYSIS.

5.1 Introduction.

The description of the tool assemblage identifies site type and the activities which occurred at the site. The tool analysis focuses on the techniques of manufacture. It follows a Bordes (1969) style of analysis where the location and nature of retouch are identified. Bordes, as a flint knapper, provided insight into the process of tool manufacture and the rational behind flake removals. Following a suggestion from Bordes (1969:8), the current tool analysis centers on the identification of the techniques of tool manufacture. These techniques were of more interpretive importance than stylistic and metrical variation, although tool metrics are presented as Appendix 18.

Bordes has defined the important portions of tools and the nature of their lithic reduction technology, which he calls 'retouch' (meaning flake removals and/or usewear). As to the nature of tools Bordes (1969:3) stated:

> it is necessary to remember that an implement most frequently has three parts: the active part, the part of prehension (or handle), and the intermediate part, which can occasionally disappear.

Bordes (1969:3) also observed that: "A Paleolithic implement can manifest three different types of retouch, differing not so much (or only) in its morphology, but especially in its origin and meaning." Three types of retouch we defined by Bordes (1969:3) as:

> first, the retouch of shaping, which transforms the rough flake or blade into a tool; second, the retouch of accommodation which, in point of fact relates to the handle of the implement and not the implement itself [e.g. the lateral retouch on an endscraper, or the notching flakes of a projectile point]; third, the retouch of utilization [...] it can appear on the serviceable part of an implement and frequently blunt its edge making it useless.

This framework of analysis is of value since the focus is on the manufacture techniques of different tool forms. In continuing with the methods of tool analysis, the following terms are defined:

Hard hammer percussion: method where flakes are removed by a hammerstone (Kooyman 2000:173). Large bulbs of percussion, eraillure scars and crushing on the platform surface are common characteristics of hard hammer flakes (Kooyman 2000:79). *Decortication* (Kooyman 2000:171), *core-reduction* and *shaping* (Kooyman 2000:176) are the main flake types.

Soft hammer percussion: method where flakes are removed by a percussor of antler, bone or wood (Kooyman 2000:177). A small diffuse bulb of percussion, presence of platform lipping, and the absence of eraillure scars are common characteristics of soft hammer percussion (Kooyman 2000:79). *Bifacial reduction* (Kooyman 2000:170) and *unifacial reduction* are the main flake types produced by this method. Some shaping does occur.

Pressure flaking: method where flakes are removed by placing pressure on a platform edge with a soft fabricator, such as a piece of bone or antler (Kooyman 2000:175). Small thin flakes, well prepared platforms and a lack of a bulb of percussion are common traits of pressure flaking. *Primary pressure retouch* and *secondary pressure retouch* are the main flake types of this method.

Bipolar: method where flakes are removed by placing an objective piece between a hammerstone and anvil (Kooyman 2000:170). Crushing on proximal and distal ends, latitudinal splitting and longitudinal breakage are common characteristics of bipolar flake removal (Kooyman 2000:170; Low 1996). A different sort of cleavage occurs with bipolar methods. Flakes have characteristics that can resemble diffuse double bulbs of percussion, and often have a planar cleavage due to a split bulb of force (Crabtree 1982; Low 1996).

Implements were analyzed to identify tool kits for each occupation. Recovered implements fell under the categories of formed and unformed tools. Formed tools were divided into bifaces and unifaces. Unformed tools were divided into retouched and utilized debitage. Throughout the tool analysis the manufacture technology was considered of greater importance than tool form, function and metrical variation.

5.2 The Below Forks Tool Analysis.

Below Forks had a great diversity of tools. Table 5.1 presents the frequency of tools retrieved from the various occupations. Importantly, very few tools were recovered from the upper and middle components. An abundance and a great diversity of tools were identified from the lower component.

Table 5.1. The tools of Below Forks, eastern area excavations.

Tool Type	Upper	Middle	Lower	Total
Hammerstones	2	0	2	4
Anvil	0	0	1	1
Bifacial Knifes	0	1	10	11
Projectile Points	0	0	3	3
Pièce esquillées	0	0	1	1
Endscrapers	0	0	6	6
Sidescrapers	0	0	3	3
General Uniface	0	0	1	1
Multipurpose Implement	0	0	1	1
Chithos/Techua	0	0	1	1
Retouched Debitage	1	2	22	25
Utilized Debitage	0	0	1	1
Total	3	3	52	58
Reverse Unifaces (included with endscrapers)			4	4

5.2.1 Upper Occupation Tool Analysis.

Hammerstones (n=2). Two granite hammerstone were recovered from the upper occupation, both were very large. (Figure 5.1). Battering was present on the object margins.

Retouched Debitage (n=1). One piece of retouched debitage occurred in the upper occupation (Figure 5.2). Small secondary pressure retouch was placed along the margins of a thermally altered flake of Swan River chert. The original flake type was indeterminate. Usewear was not evident on the piece.

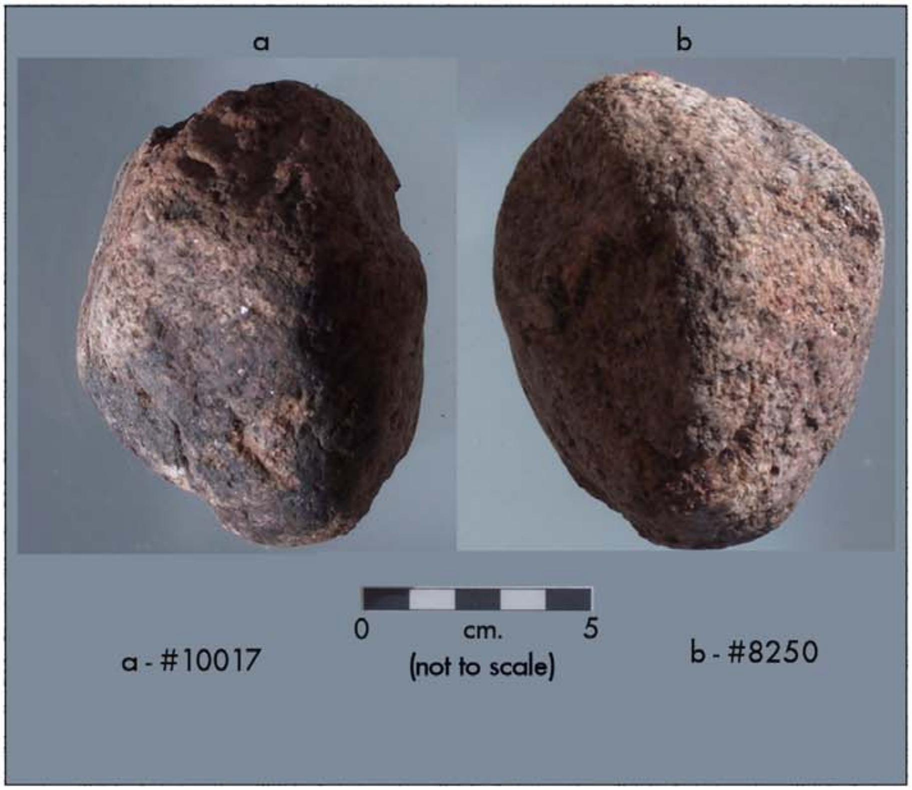


Figure 5.1. Upper occupation hammerstones.

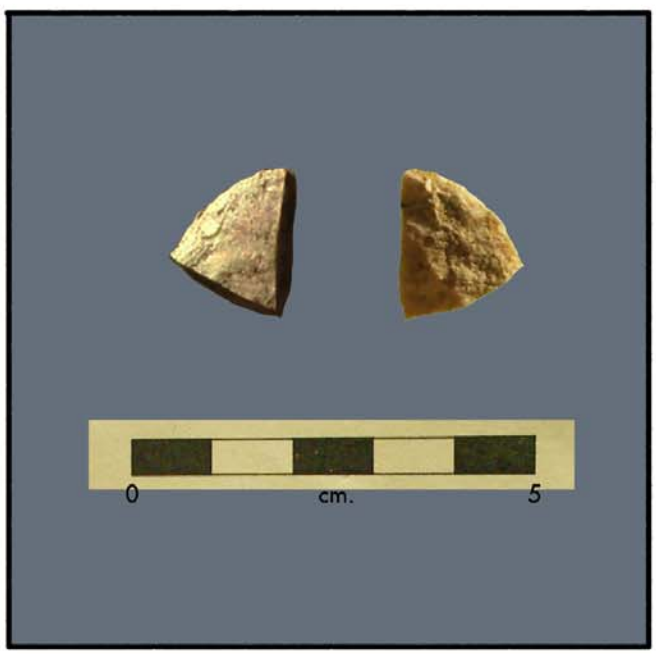
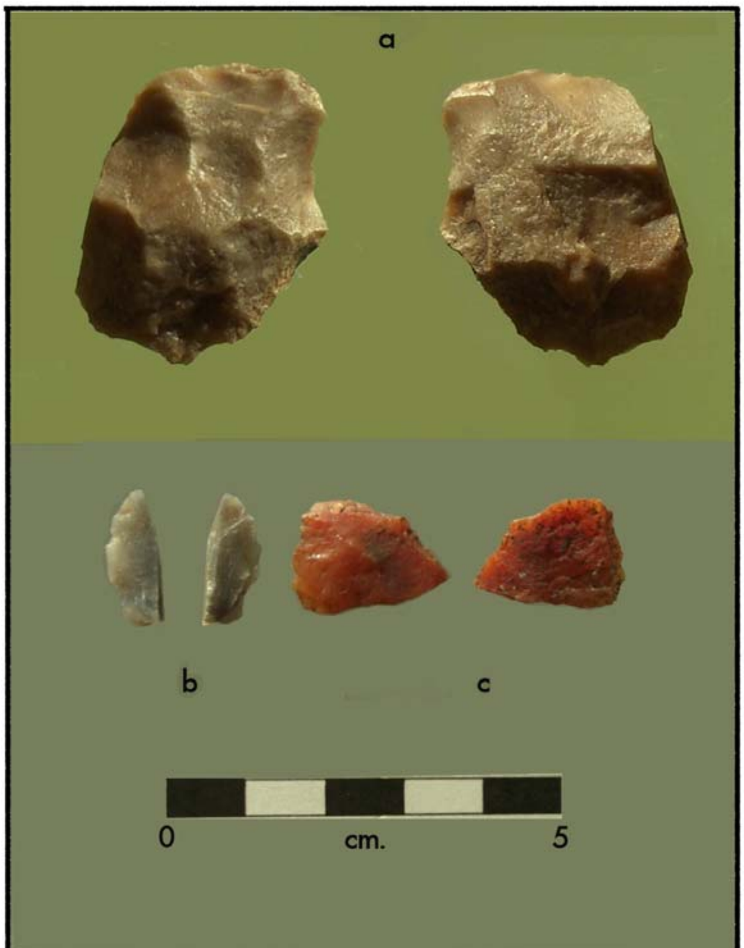


Figure 5.2. Upper occupation retouched flake (#7466).

5.2.2.Middle Occupation Tool Analysis.

Biface (n=1) One fragmented biface manufactured on thermally altered Swan River chert was recovered from the middle occupation (Figure 5.3, a). The implement was formed by bifacial reduction on both faces. The piece was finished with primary and secondary pressure retouch along the margins. Usewear was not present on the item.

Retouched Flake (n=2). Two retouched flakes of thermally altered Swan River chert were recovered from the middle occupation (Figure 5.3, b and c). Primary pressure retouch was present along the lateral margin of flakes of indeterminate type. Usewear was not present.



a - #7125 bifface	b - #7138 retouched flake	c - #6093. retouched flake

Figure 5.3. Middle occupation tools.

5.2.3 Lower Occupation Tools.

Projectile Points (n=3). Projectile points were originally formed by shaping and/or bifacial reduction on both faces (Figure 5.4). Primary pressure retouch was placed along the lateral sides and distal tips. Secondary pressure reduction was placed along the entire edge of the dorsal surface, and usually was only present on a portion of the ventral surface. The cross sections were bi-convex (n=2) or asymmetrically twisted (n=1). Item 11076 was a projectile point tip; item 11077 was a nearly complete point, with some breakage at the base. Item 4144 was a complete projectile point, with a straight base and corner notching. The base and notches of the points were ground to prevent cutting of the haft ligature (Knecht 1997:201-202). These items (11077 and 4144) were diagnostic to the Early Side-notched/Mummy Cave series. An additional projectile point was recovered at a depth of 50 cm. from the cutbank exposure on the western side of the excavation block (item 11089). It was a base of an Early Side-notched point manufactured from quartz exhibiting excellent workmanship. The piece had a straight base, bi-convex cross section and straight side notches. The paucity of tools and quartz debitage from the middle occupation suggest that the point was associated with the lower component.

Pièce Esquillées (n=1). A pièce esquillées was manufactured from an indeterminate black chert (Figure 5.5). The piece was formed by bidirectionally oriented shaping and slight bifacial reduction. The lateral margins of both faces were well formed by primary pressure retouch. Heavy grinding and crushing from use were present on the lateral margins (Brink et al. 1986:137). Such items were used to work organic materials, especially soft wood (Keeley 1980:34-42). The cross section was bi-convex to rectangular.

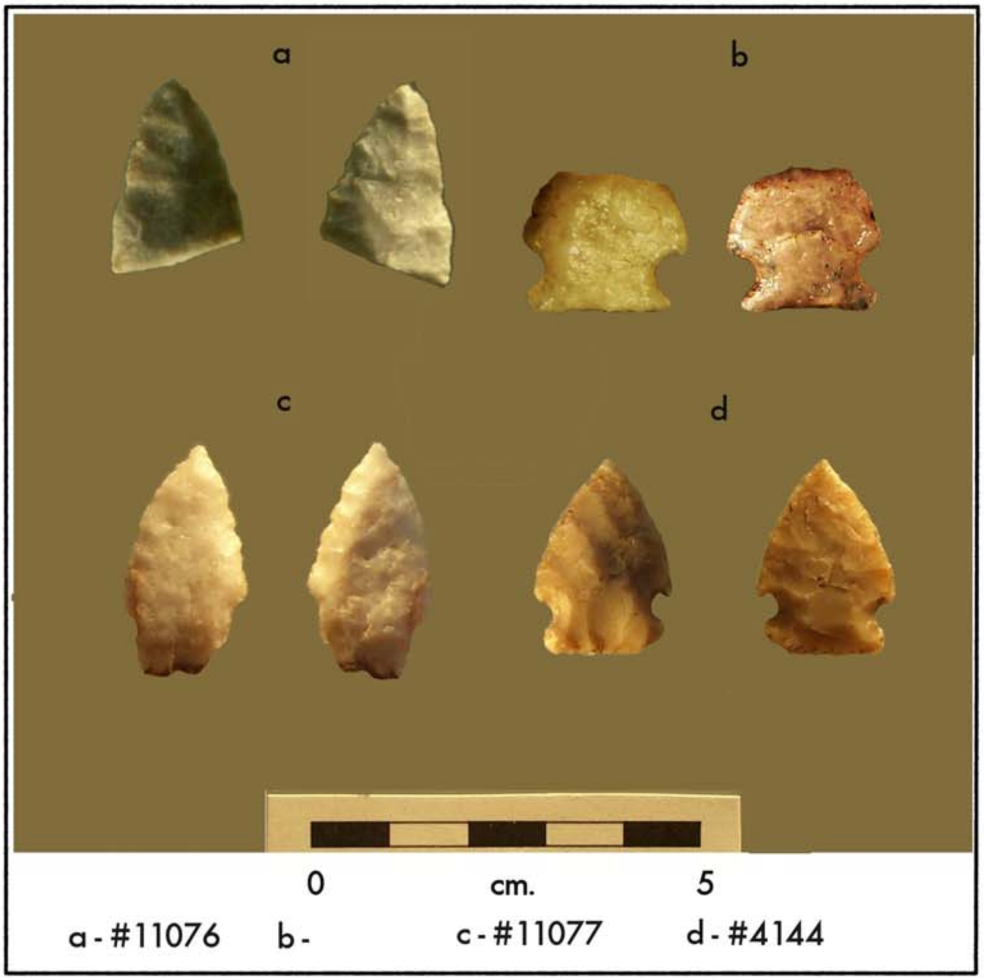


Figure 5.4. Projectile points.

Figure 5.5 Pièce esquillées. (#7855)

Bifaces (n=10). Ten bifaces were recovered from the lower occupation (Figure 5.6 and 5.7). Bifaces were manufactured with hard and soft hammer shaping, bifacial reduction, primary and occasionally secondary pressure retouching. Often these bifaces were broken and thus discarded. Nine bifaces were broken; a single biface was recovered complete. Most of the bifaces were broken after manufacture and use (n=7 of 9), evident by flake scars going across the fractures and the presence of usewear. Two items were broken during manufacture. Bifacial usewear consisted of wide-step fractures (n=1), tiny step fractures (n=5)(Ahler 1979), and smoothing (n=5). The usewear indicated that the implements were for cutting organic materials (Keeley 1980:53-55; Prentice 1983:155-156). The bifaces were manufactured from thermally altered SRC (n=9) and quartz (n=1).

Chithos-Like Implement (n=1). A sandstone chithos-like implement was recovered (Appendix 19.1). The item had a distal edge ground from use, likely as a heavy scraper of organics. The best evidence supporting the interpretation of the object as a tool is its context in the centre of a living floor.

Hammerstones (n=2). Two complete granite hammerstones were recovered (Appendix 19.2). They were of a medium size and had significant amounts of pecking along their margins.

Multipurpose Tool (n=1). A complete multipurpose pecked and ground gneiss stone tool manufactured was recovered (Appendix 19.1). The item had some hard hammer decortication flake removals from the proximal and lateral edges on both surfaces. The ventral surface was smoothed and ground through use as an abrader. The distal edge showed pecking indicative of hammering. The proximal edge had pecking and wear from use as a chopper. Therefore, the implement was used as a hammerstone, chopper, and abrader.

Anvil (n=1). A large granite anvil was recovered (Appendix 19.3). It had large battered depressions in the centre of both surfaces. The anvil was used for lithic reduction, evident with a spatial association to bipolar cores and flakes. Koybayashi (1975) suggested that the heavier the anvil the better. This anvil received heavy duty use.

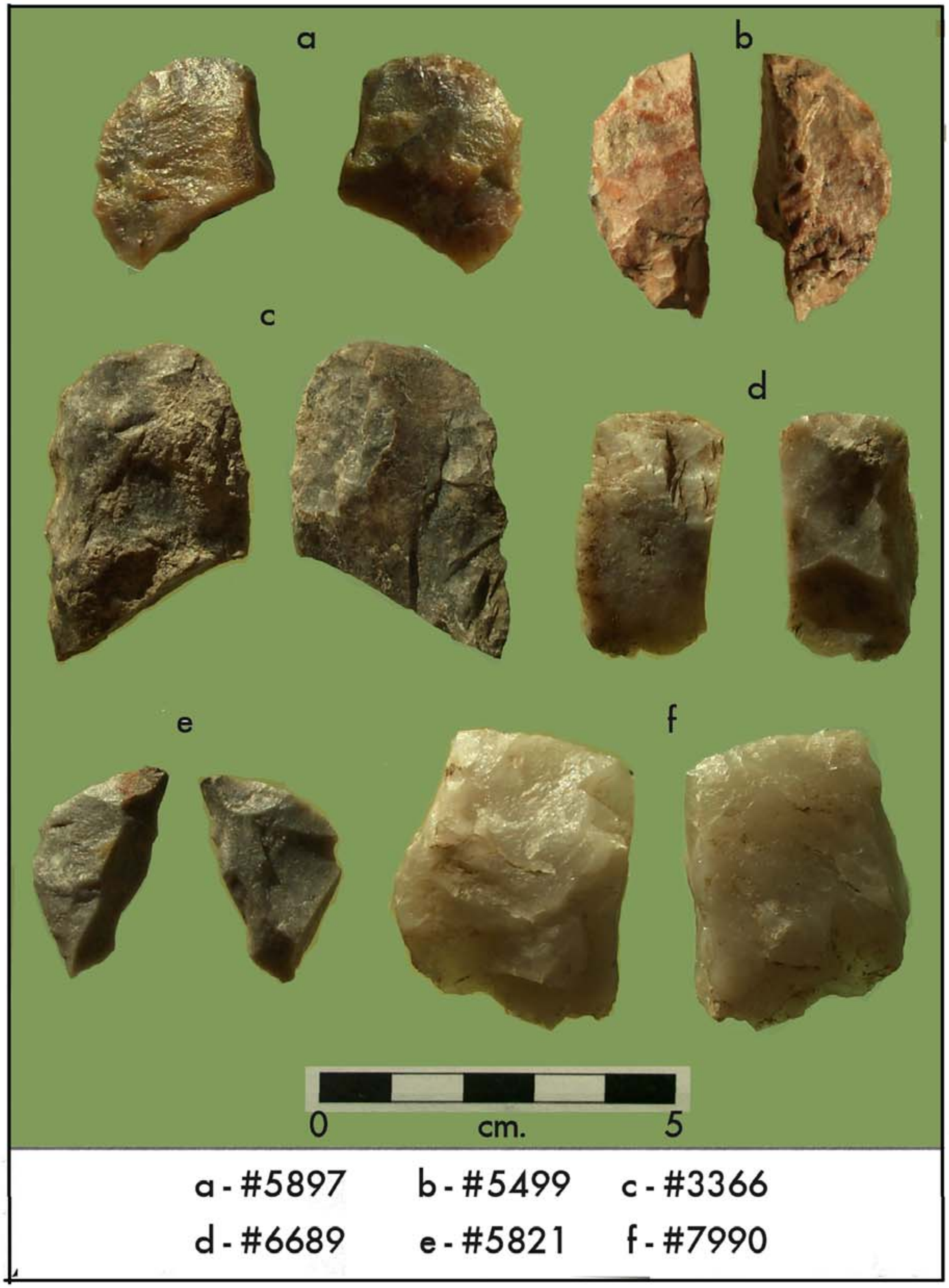
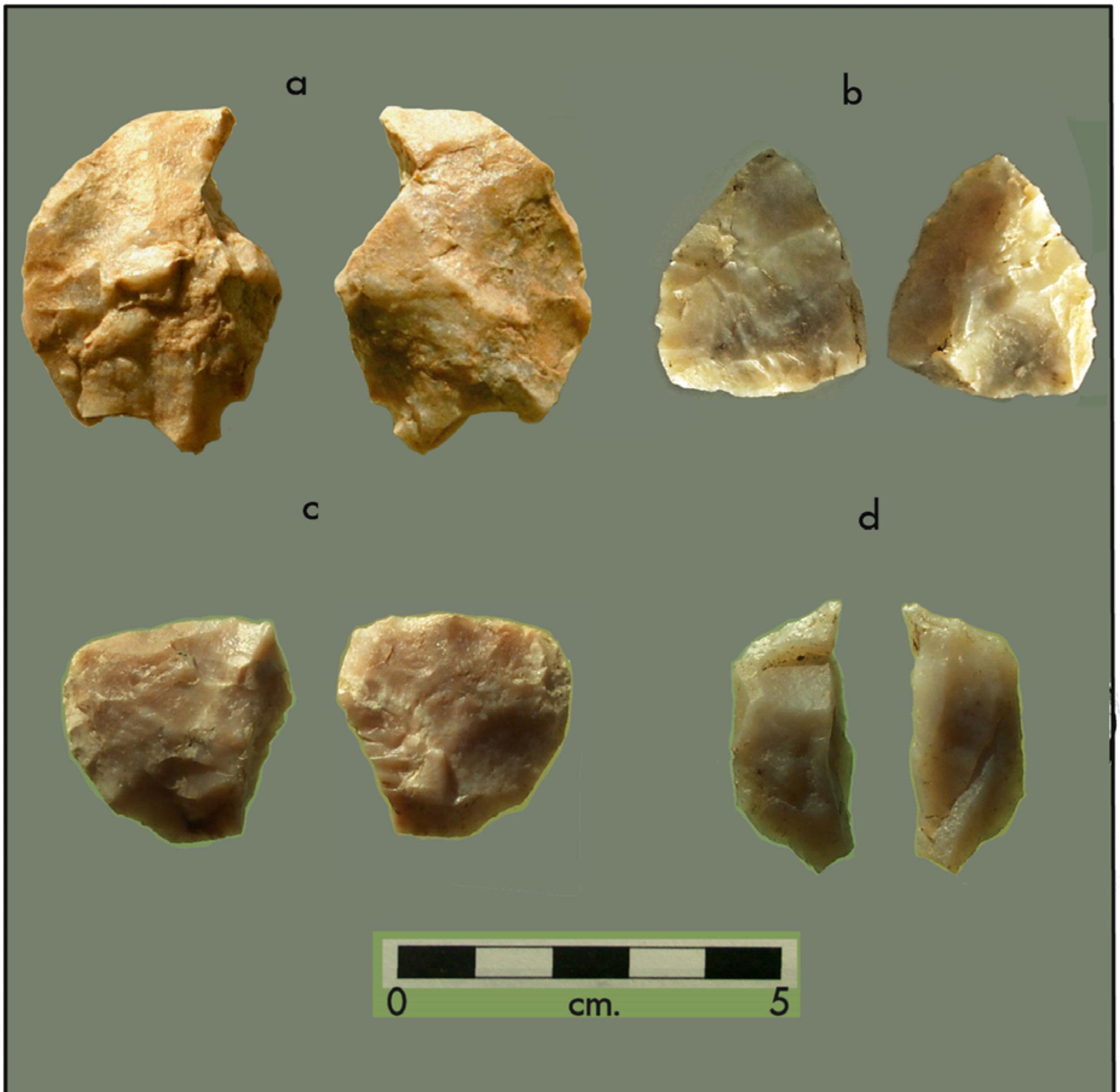


Figure 5.6. Bifaces, part one.



a - #3932 b - #11078

c - #5061 d - #1156

Figure 5.7. Bifaces, part two.

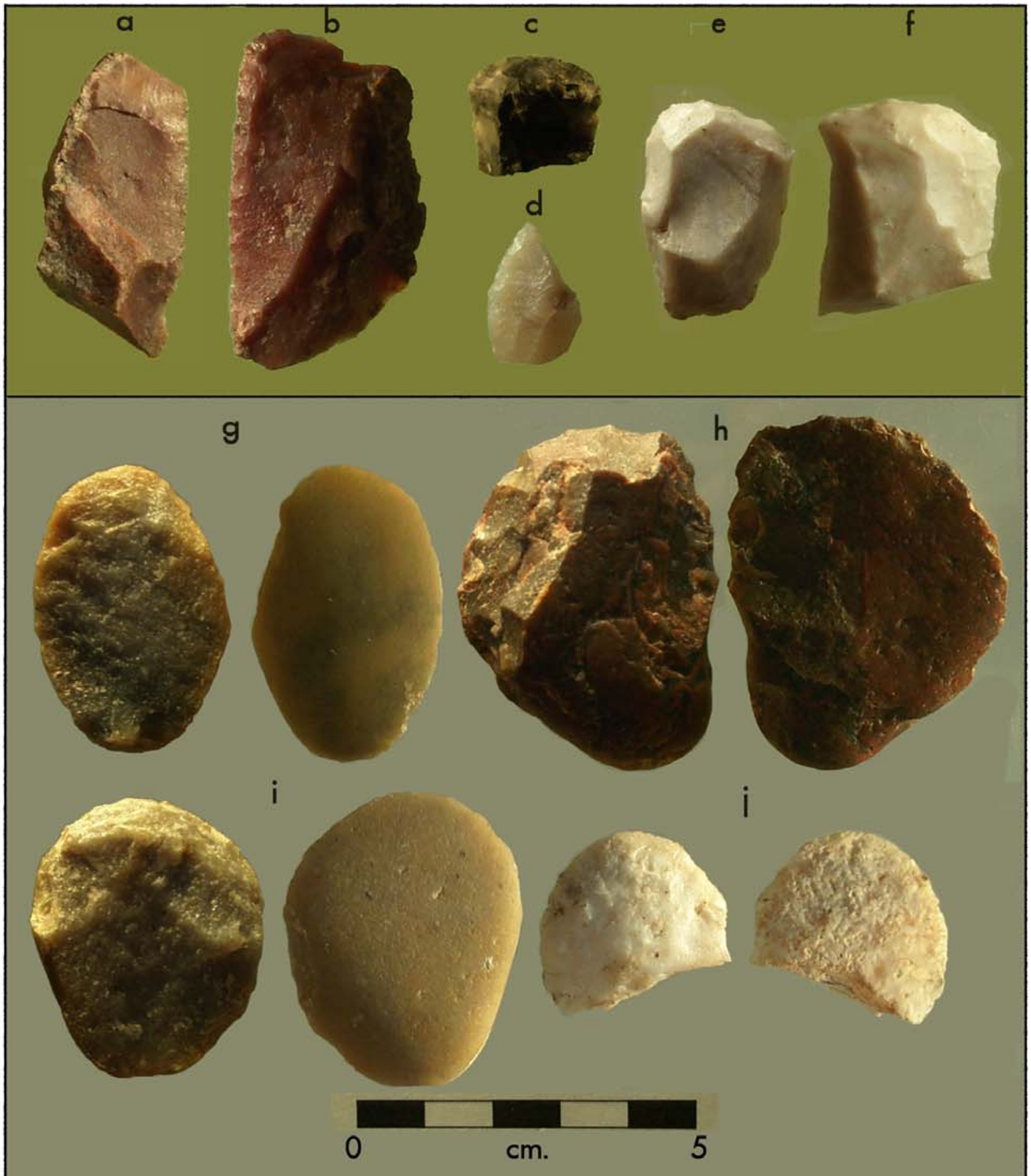
Unifaces (n=10). The unifaces recovered from the lower component are illustrated in Figure 5.8. Unifaces were manufactured with regular and reverse methods. Reverse unifaces were fashioned on decortication flakes struck with the hard hammer bipolar technique. The working edge was formed by unifacial reduction and occasional pressure retouch flakes positioned on the former bipolar platform. The idea behind the reverse form was to use the cortex as the ventral surface, which is in opposition to the standard location of cortex on the dorsal surface. Figure 5.9 illustrates the technological distinction between regular and reverse unifaces. Table 5.2. presents a summary of the unifaces recovered from this component.

Six unifaces were manufactured with the regular method. Hard hammer flake blanks (n=5) and a bipolar core (n=1) were worked into these unifaces. Shaping and unifacial reduction formed these tools. Primary and occasional secondary pressure retouch occurred along the working edges. The area of prehension was usually kept rough and was not retouched. The items had plano-convex or bi-bevel plano convex cross-sections. Usewear was present as small step fractures (n=2)(Ahler 1979), tiny step fractures (n=2)(Prentice 1983:168-177), and smoothing (n=1)(Brink 1978:47). Usewear was most significant on the dorsal surface, and subtle small but broad step fractured flake scars were often present on the ventral surface of the working edge. Regular unifaces were manufactured from thermally altered Swan River chert. Of interest is that the side scraper was manufactured from a bipolar core. The indeterminate uniface was a small fragment of a tool broken after manufacture and use.

Table 5.2. Uniface form by tool type.

Unifaces	Frequency	Manufacture Method	
		Regular	Reverse
Endscrapers	4	3	1
End-sidescrapers	4	1	3
Sidescraper	1	1	0
Indet. Uniface	1	1	0

Four reverse unifaces were recovered from the lower component. Usewear was present on three of the reverse unifaces. It occurred as smoothing (n=2)(Brink



a - sidescraper - #3135 b - sidescraper - #4231 c - endscraper - #5062
d - indet. uniface - #813 e - endscraper - #2663 f - endscraper - #7869
g - reverse uniface - #4236 h - reverse uniface - #5062
i - reverse uniface - #1153 j - reverse uniface - #11075

Figure 5.8. Unifaces.

1978:47) and as small step fractures (n=2)(Prentice 1983:168-177). Usewear occurred only on the dorsal surface of two implements and was expressed on both surfaces of a single item. The usewear indicated that these implements worked hide and other organic materials (Keeley 1980:49-53; Prentice 1983:155-177). Reverse unifaces were manufactured of quartzite, pebble chert and SRC. Table 5.3 summarizes the material types of the recovered unifaces. The tool breakage pattern of the unifaces, as depicted on Table 5.4, indicated that 67 % of the regular endscrapers were broken, while all of the reverse unifaces were recovered complete. This pattern suggests that the reverse unifaces were not utilized for a long period of time, or that they were more durable than regular unifaces.

Table 5.3. Uniface material types.

Method	Regular	Reverse		
Material Type	SRC, Heat.	SRC, Heat.	Quartzite	Pebble Chert
Endscrapers	3	1	2	1
End-sidescrapers	1	0	0	0
Sidescraper	1	0	0	0
Indet. Uniface	1	0	0	0

Table 5.4. Uniface breakage.

Unifaces	Normal			Reverse		
	Normal	Complete	Broken	Reverse	Complete	Broken
Endscrapers	3	1	2	1	1	0
End-sidescrapers	1	1	0	3	3	0
Sidescraper	1	1	0	0	0	0
Indet. Uniface	1	0	1	0	0	0

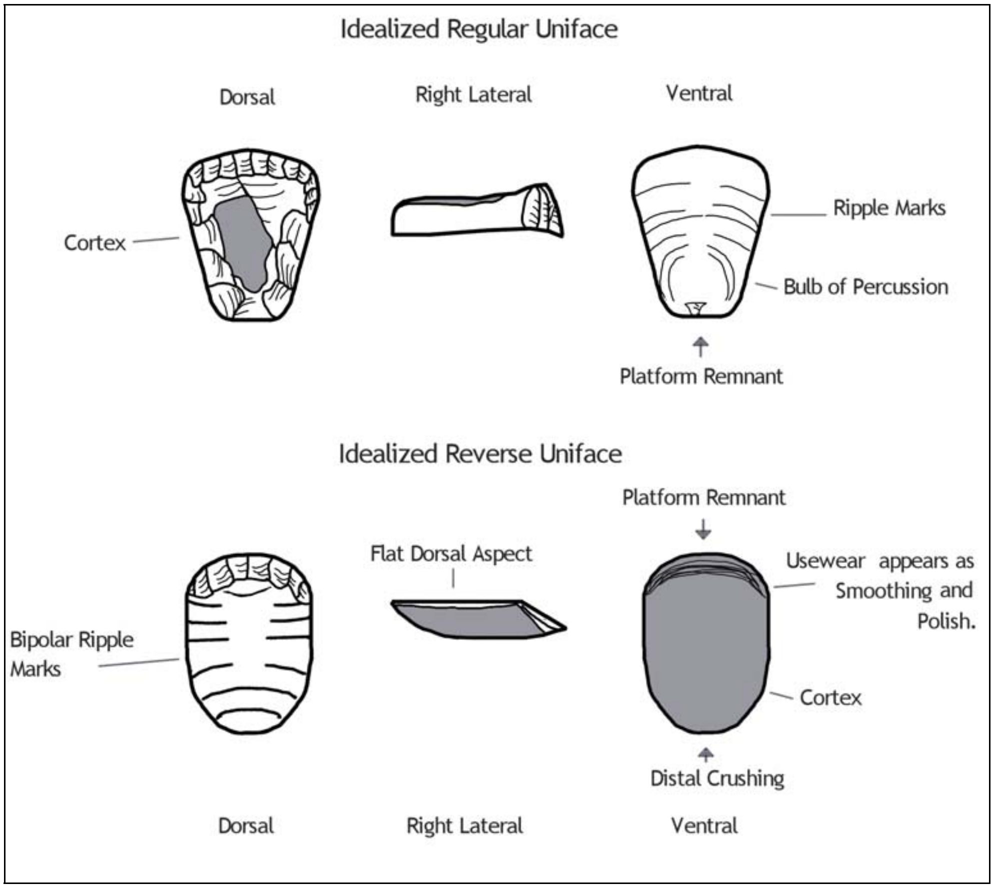


Figure 5.9. Diagram of idealized regular and reverse unifaces.

Retouched Debitage (n=22). All retouched debitage identified from the lower component were formed by primary and secondary pressure retouch along lateral edges (Figure 5.10). Retouched debitage were separated into bifacial retouched items (n=10) or unifacial retouched items (n=11). One unique piece of retouched debitage was present in the assemblage. It was a bifacially retouched piece of shatter which had usewear consistent with a cutting tool (Prentice 1983:155-156). The implement was a large block of thermally altered SRC with a bifacial edge jutting out of the shatter.

Utilized Debitage (n=1). One utilized shaping flake of Red River chert was present in the assemblage (Figure 5.11). Usewear was present along a lateral margin as small flake scars, and the occasional large flake scar (Ahler 1979). The item was interpreted as a cutting tool (Prentice 1983:155-156; Keeley 1980:53-55) and had a triangular cross section. There were relatively few items of retouched or utilized debitage in the assemblage (22 of 28 388 pieces of debitage). Therefore, flake production related to tool manufacture and not for flakes as expedient tools.

a - #5033 b - #8595 c - #5059 d - #8350 e - #5303 f - #779 g - #8391
h - #4235 i - #7854 j - #9517 k - #4157 l - #4161 m - #2671 n - #747 o - #778
p - #2029 q - #10657 r - #4305 s - #7972 t - #7675 u - #1976 v - #5058

Figure 5.10. Retouched debitage.

Figure 5.11. Utilized debitage (not to scale).

5.3 Reverse Unifaces: A Discussion.

The technology of the reverse uniface appears to have been geographically and chronologically distinct. The use of cortex on the ventral surface of unifaces makes them readily identifiable. Reverse unifaces have been recovered from a variety of sites on the Northern Plains and are absent in the Boreal Forest. The largest collection of reverse unifaces is from an undated cache in site EgNp-63 from the edge of Lake Diefenbaker (Johnson 1994:80-82). All the unifaces from this site were manufactured from quartzite. Reverse unifaces have also been recovered at sites EqNq-18 and EgNr-2 on the shore of Lake Diefenbaker (Stevenson 1990:3-4). The Gowen site had 60 reverse unifaces which Walker (1992) identified as "gouges". These were also manufactured from quartzite (Walker 1992:55-58,83-85). Reverse unifaces have been found at the Anderson site in southeastern Alberta (Quigg 1984:154). These specimens were manufactured out of quartzite. Two reverse unifaces were identified from the East Village Access site in Batoche National Historic Site (Kasstan 2003). A reverse uniface has been discovered from the Niska site, in an undated surface collection associated with Oxbow complex materials (Meyer 1985:5). A reverse uniface was recovered from the surface of FgNh-58 on a middle level terrace of the South Saskatchewan river near the Birch Hills ferry (Wilson 1982:946-947). Reverse unifaces were almost always manufactured out of quartzite and are rarely recovered broken or fragmented. Table 5.5 provides radiocarbon dates of sites that contain reverse unifaces. Clearly they appear to be of Mummy Cave series antiquity, in the range of 6700 to 4700 rcybp. Figure 5.12 shows the distribution of all known recoveries of reverse unifaces.

Table 5.5. Radiocarbon dates of sites with reverse unifaces.

Site	Sample Number	Normalized Date		error	Reference
East Village Access	S-2739	6825	.+/-	95	Kasstan 2003; Morlan 2003.
East Village Access	S-2737	6635	.+/-	185	Kasstan 2003; Morlan 2003.
East Village Access	S-2738	6480	.+/-	100	Kasstan 2003; Morlan 2003.
Gowen 1	S-1457	6230	.+/-	110	Walker 1992; Morlan 2003.
Gowen 2	S-1971	6160	.+/-	160	Walker 1992; Morlan 2003.
Gowen 1	S-1488	6150	.+/-	260	Walker 1992; Morlan 2003.
Below Forks	TO-9354	6100	.+/-	140	Meyer 2000; Morlan 2003.
Below Forks	TO-9355	6010	.+/-	80	Meyer 2000; Morlan 2003.
Gowen 2	S-1970	6000	.+/-	130	Walker 1992; Morlan 2003.
Gowen 2	S-2036B	5990	.+/-	170	Walker 1992; Morlan 2003.
Below Forks	TO-11027	5920	.+/-	60	This volume.
East Village Access	S-2740	5740	.+/-	90	Kasstan 2003; Morlan 2003.
Gowen 2	S-2037	5670	.+/-	110	Walker 1992; Morlan 2003.
Anderson	GX-6130	5540	.+/-	160	Quigg 1984; Morlan 2003.
Below Forks	TO-10083	5520	.+/-	60	This volume.
Gowen 1	S-2036 A	5160	.+/-	150	Walker 1992; Morlan 2003.
Gowen 1	S-1526	4810	.+/-	130	Walker 1992; Morlan 2003.
Anderson	GX-6129 G	4805	.+/-	150	Quigg 1984; Morlan 2003.

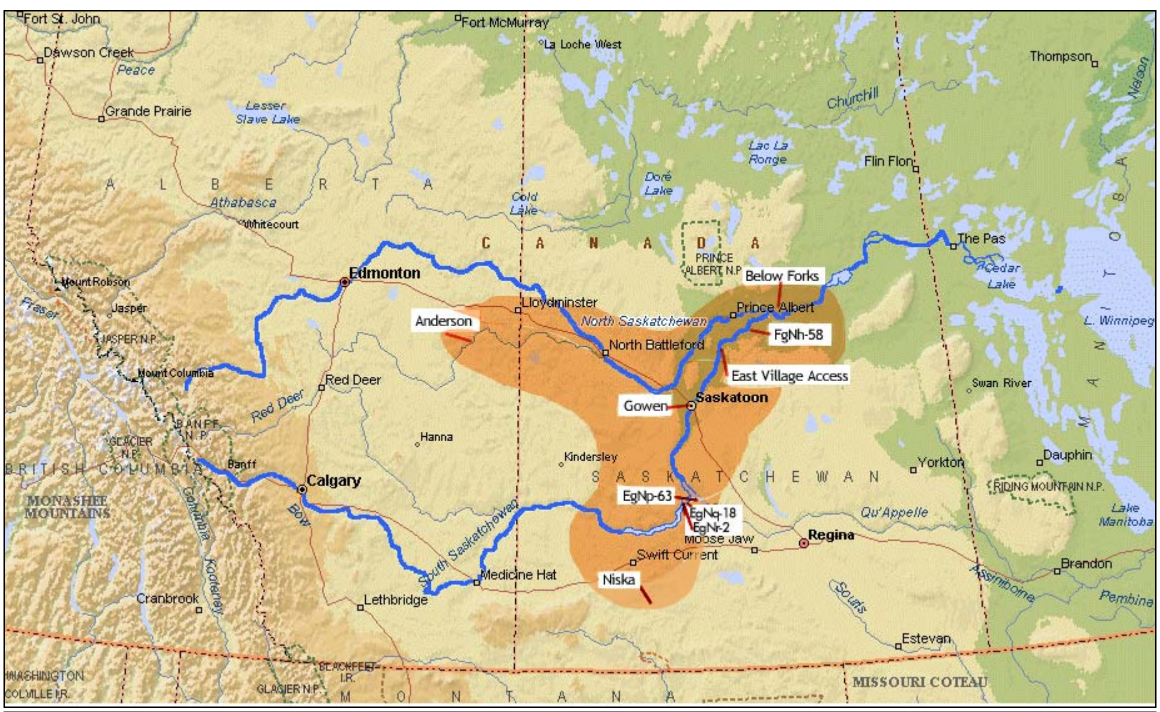


Figure 5.12. The distribution of the reverse uniface tool type.

(base map courtesy of the University of Guelph)

5.4 Pièces Esquillées: A Discussion.

Pièces esquillées are a most problematic category of tool. They are difficult to identify, have a unique relationship with bipolar technology and have a poorly understood situation in Northern Plains culture history. Three definitions of pièces esquillées clarify the technological situation. Kooyman (2000:175) defined pièces esquillées as:

> Thin pieces of lithic material used as a wedge by hammering the piece into the material being worked (e.g., wood or bone); characterized by battering on both the hammered end and the end that entered the worked material.

Gordon (1996:70) defined pièces esquillées as:

> bashed stone tool for splitting soft wood, hard antler, or bone. May be hit unipolarly or bipolarly (one or both ends), double bipolarly, or discoidally. Wood splitting results in unipolar percussion and channel flakes from the hammer stone; the opposite end is seldom smashed due to softer wood. Wedges used on antler or bone are often discoidally hit because bashing around the periphery disperses hammerstone blows and prolongs the life of the wedge.

Bordes (1969:4) on observing usewear stated that :

> It can also exist on pieces of flint (flakes or blades) which without it would remain rough; this is the case with the pièces esquillées or with the *lames et éclats à mâchures* (crushed blades and flakes), which are thereby posthumously transformed, so to speak, from rough objects into implements.

Essentially Bordes stated that the extensive usewear on pièces esquillées is a defining feature of the tool. These definitions agree that pièces esquillées are technologically formed through use rather than along a pre-existing mental template roughed out and finished by intentional flaking. It is this aspect that make the identification of these tools difficult and contributes to their possible misidentification. There has been debate regarding their use as expediency tools, woodworking, bone incising, soft stone working tools, and/or just bipolar cores (LeBlanc 1992; MacDonald 1968; Magne 1985:168; Shott 1989). The bipolar nature of pièces esquillées is evident with bipolar flake removals (mainly from use) and longitudinal splitting and breakage. Notably, pièces esquillées are very distinct from bipolar cores. Purposeful forming and usewear are key traits that separate these tools from bipolar cores.

Pièces esquillées are rare in archaeological collections from the Northern Plains. Kooyman (2000:114,120) stated that pièces esquillées have been found in Agate Basin sites, and in Mummy Cave sites and does not mention them in other cultures. To expand on Kooyman, pièces esquillées were recovered from the Cody complex at the Horner site (Frison and Todd 1987:251-254), McKean complex levels of the Cactus Flower site (Brumley, 1975:53), and from the late precontact occupations at the Estuary Bison Pound Site (Adams 1977:188) and at Head-Smashed-In (Brink et al. 1985:140; Brink et al.1986:134-137; Brink and Dawe 1989:227,233-234). Pièces esquillées are recovered from all cultural periods of the Boreal Forest (Gordon 1996). It is likely that these tools are more prevalent in the Northern Plains, but have been misidentified. As more pièces esquillées are identified, their situation in Northern Plains culture history will become clear.

5.5 Projectile Points of Below Forks.

It is difficult to associate the projectile points from the lower occupation of Below Forks with a sub-group of the Mummy Cave series. The point tip (Item 11076) was obviously non-diagnostic. The specimen with a broken base (Item 11077) was rather non-descript. An asymmetrical (twisted) cross-section was observed on the item. This artifact was likely a preform. Item (11089) is a broken side-notched projectile point manufactured from quartz. The point tip has broken off, leaving a sheared step fracture on the distal end, and a step terminated flake scar on the ventral surface. These observations are consistent with an impact break. The basal edge and notches has been ground for hafting. This point corresponds to the Gowen projectile type.

The third projectile point (Item 4144) was both similar and remarkably different from Gowen projectile points. The straight base, basal thinning, basal grinding and notch position are consistent with the Gowen type. The right notch was slightly, but quite noticeably, placed higher up on the body than the left notch. This was a very common intentional feature on Gowen projectile points (Walker 1992: 43-45). This feature likely related to diagonal sinew winding of the point to an atlatl shaft or fore-shaft. The noticeable difference of specimen 11077 is that it was corner-notched, where the right notch appeared nearly tanged. Corner-notching was uncommon in the

Mummy Cave series, but not rare. Corner notching appeared at the earliest sites of the Mummy Cave series in the Northern Plains, being present at the Boss Hill (Doll 1982) and Itasca (Shay 1971) sites. Novecosky (2002:77-84) identified a Large Corner-notched point type from the Quill Lakes area and hypothesized a date of circa 7500 rcybp. Below Forks is not of this antiquity; the projectile points recovered from the lower occupation belong to the Mummy Cave series. Due to the limited sample size, these items are tentatively identified as Gowen-like points. A larger sample of projectile points would clarify the situation.

5.6 Summary.

The upper and middle occupations were sparse and without diagnostic tool forms. A hammerstone and a retouched flake were recovered from the upper occupation. A biface and a retouched flake were discovered from the middle occupation. The lower occupation was relatively rich, and had a density of about two tools for every excavated unit. Many bifaces were retrieved from this occupation, including a pièces esquillées and Early Side-notched projectile points reminiscent of Gowen forms. A variety of unifaces were uncovered, including three endscrapers and a side-scraper. Four reverse unifaces were also found, and are diagnostic to the Early Side-notched/Mummy Cave series. The tool assemblage indicates tool manufacture was the most important activity at the site. A diverse suite of activities occurred at the site, these include hunting, butchering, hide-working and some organic processing.

"A scattered dull day - the answer to what is life?
Do we always grind through the present,
Doomed to throw a gold haze
of fond retrospect over the past."

Sylvia Plath (2001:336-337),
From her journal, February 22, 1958.

6. ANALYSIS OF CORES, OCHRE, AND FIRE CRACKED ROCK.

6.1 Introduction

This chapter presents the analysis of cores, red ochre and fire cracked rock. Cores were analyzed to further interpret and confirm the interpretations of lithic technology. Baumler (1988:256-257) and Kuhn (1995:31-32) suggest some general advantages of core analyses. The cultural significance and regional sources of red ochre are also briefly discussed. A short description of fire cracked rock concludes the chapter.

6.2 Core Analysis

6.2.1 Definitions for the Core Analysis.

Cores were analyzed in detail and allowed for an interpretation of lithic technology independent of the debitage. The analytical focus was on the identification of core type, material type, basic metrics, and core preparations, including thermal alteration and platform preparation. The definition of core types was essential for analysis. Core types were defined as follows:

Bifacial core: a core worked on two surfaces, where flakes are removed from platforms located along the piece's circumference (Silva 1997:24).

Bipolar core: a core reduced on an anvil, with opposing bi-directional flaking along the long axis of the core (Low 1997:261-264).

Amorphous core: a core that has multidirectional flake removals (at least three), and lacks a distinct form. These cores often have the appearance that flakes were struck off opportunistically (Kooyman 2000:100; Silva 1997:36)

Flake core: a flake with a prominent original platform, and which has a flake removed across the ventral surface. Silva (1997:37) defines a flake core as:

> A flake that has been used as a core. It is sometimes difficult to differentiate between flake cores and flake tools, and in some cases there may be no real difference between the two. In general, flake cores are expected to be made on exceptionally large flakes and to lack the small, regular retouch scars that mark flake tools.

Platform core: Unidirectional core with flakes struck off from the same platform (Silva 1997:24).

Tested Cobble: Silva (1997:37) defines a tested piece as an "otherwise unaltered piece of raw material from which one or two flakes have been removed".

6.2.2 Cores - Upper Occupation

A variety of cores were present in the upper occupation (n=16). Five amorphous, seven bifacial, two bipolar, one flake and one indeterminate core were present. Swan River chert was the preferred raw material occurring on 14 cores. An individual core was of an indeterminate chert type, while a single quartz core was present. Notably, 62 % of the cores of the upper occupation exhibited platform preparations. Surface flaking was the preferred platform preparation for bifacial cores. Platform edge grinding and surface flaking were applied to the amorphous cores. Bipolar cores exhibited platform surface flaking and the definitive crushing. Thermal alteration was observed on 75 % of the cores from the upper occupation.

6.2.3 Cores - Middle Occupation.

A small number of cores were present in the middle occupation (n=5): two bifacial, two bipolar and one indeterminate. Of these, 80 % exhibited some form of platform preparation. Surface flaking, edge grinding and surface grinding were present on the bifacial cores. The bipolar cores had platform edge and surface grinding, surface flaking and crushing. Since there were so few cores in this occupation, their preparation strategies cannot be strongly interpreted. Three cores were manufactured from SRC. One core was composed of quartzite and another was of siltstone.

6.2.4 Cores - Lower Occupation

A large quantity of cores was recovered from the lower occupation (n=85). The proportion of core types was as follows: 19 amorphous, 33 bifacial, 18 bipolar, 2 flake-cores, 2 tested cobbles and 11 indeterminate cores. The indeterminate cores were mainly core fragments. Interestingly, flake cores were recovered. These were large flakes subsequently used to produce flake-blanks. Recovery of tested cobbles was also of interest. Tested cobbles identify selected materials that were examined for further reduction but were discarded without additional knapping, indicating a material rejection. In both cases the tested cobbles were of poor lithic quality.

A wide variety of raw material was represented in the assemblage of cores. There were 77 SRC cores, two quartzite cores, and individual cores of Red River chert, limestone, quartz, siltstone and silicified wood. Platform preparation occurred on 70% of all cores. Bifacial and bipolar cores received the greatest amount of preparation. Bifacial cores were prepared with platform edge grinding. Edge and surface crushing was observed on the platforms of bipolar cores. In this situation crushing was not a purposeful type of preparation for bipolar cores. Instead it represented a defining characteristic of bipolar cores. As to true platform preparations, bipolar cores had edge and surface grinding. Amorphous cores exhibited some preparation by platform edge grinding. Thermal alteration of cores was common in the lower occupation. Distinct forms of platform preparation occurred with bipolar, bifacial and amorphous reduction strategies. A bipolar reduction strategy was present. It had prevalent surface flaking and equal portions of edge and surface grinding of platforms. A bifacial core reduction strategy was present. It consisted of thermal alteration, preferred platform edge grinding, edge flaking and surface flaking. An amorphous core reduction strategy was identified. It had surface flaking and edge grinding as preferred forms of platform preparation.

6.2.5 Core Analysis Summary.

A wide variety of cores were recovered in the three occupations of the Below Forks site, and are summarized on Table 6.1. It is noteworthy that less bipolar reduction occurred in the upper occupation compared to the lower, and that less core-reduction occurred in the middle occupation.

Table 6.1. Core types by occupation.

Occupation	Amorphous	Bifacial	Bipolar	Indet.	Flake-Core	Tested Cobble	Platform Core	Total
Upper	5	7	2	1	1	0	0	16
Level 3	0	2	0	0	0	0	0	2
Middle	0	2	2	1	0	0	0	5
Level 7	0	1	1	3	1	0	0	6
Lower	19	33	17	11	2	2	1	85

The material types of cores were summarized by component on Table 6.2. Swan River chert was the most common material for core reduction in all components. Gronlid siltstone and Red Willow Creek silicified sandstone were reduced at the site, as indicated by recoveries of debitage. Cores of these materials were not recovered. Similarly the minute quantities of agate, silicified peat, chalcedony, and basalt debitage are not represented by cores. One can infer that preforms or tools of these materials were reduced at the site, though this cannot be definitively proven.

Table 6.2. Material type of cores by occupation.

Occupation	SRC	RRC	Indet Chert	Limestone	Quartz	Quartzite	Siltstone	Sil. Wood	Total
Upper	14	0	1	0	1	0	0	0	16
Level 3	2	0	0	0	0	0	0	0	2
Middle	3	0	0	0	0	1	1	0	5
Level 7	6	0	0	0	0	0	0	0	6
Lower	77	1	0	1	1	2	1	1	84
Occupation	SRC	RRC	Indet Chert	Limestone	Quartz	Quartzite	Siltstone	Sil. Wood	Total
Upper	88%	0%	6%	0%	6%	0%	0%	0%	16
Level 3	100%	0%	0%	0%	0%	0%	0%	0%	2
Middle	60%	0%	0%	0%	0%	20%	20%	0%	5
Level 7	100%	0%	0%	0%	0%	0%	0%	0%	6
Lower	92%	1%	0%	1%	1%	2%	1%	1%	84

The platform preparations of cores were analyzed to infer technological patterns of reduction. Table 6.3 summarizes the preparation of cores by occupation. Noteworthy is the separation of preparation into the material change caused from thermal alteration, and platform preparation produced by flaking, grinding and crushing of either the platform surface or exterior platform edge.

Table 6.3. Platform preparation of cores by occupation and type.

Upper Occupation			Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grind	Edge Crush	Edge Flake	Surface Grind	Surface Crush	Surface Flake	Yes	Maybe	No	N/A
All	16	63%	38%	13%	6%	25%	6%	63%	75%	0%	13%	13%
Amorphous	5	40%	20%	0%	0%	0%	0%	40%	80%	0%	20%	0%
Bifacial	7	86%	57%	14%	14%	57%	0%	86%	86%	0%	0%	14%
Bipolar	2	50%	50%	50%	0%	0%	50%	50%	50%	0%	0%	50%
Level 3			Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grind	Edge Crush	Edge Flake	Surface Grind	Surface Crush	Surface Flake	Yes	Maybe	No	N/A
All	2	100%	50%	0%	0%	100%	0%	100%	100%	0%	0%	0%
Bifacial	2	100%	50%	0%	0%	100%	0%	100%	100%	0%	0%	0%
Middle Occupation			Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grind	Edge Crush	Edge Flake	Surface Grind	Surface Crush	Surface Flake	Yes	Maybe	No	N/A
All	5	80%	60%	20%	0%	60%	20%	60%	60%	0%	0%	40%
Bifacial	2	100%	100%	0%	0%	100%	0%	100%	50%	0%	0%	50%
Bipolar	2	100%	50%	50%	0%	50%	50%	50%	50%	0%	0%	50%
Indeterminate	1	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
Level 7			Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grind	Edge Crush	Edge Flake	Surface Grind	Surface Crush	Surface Flake	Yes	Maybe	No	N/A
All	6	50%	33%	0%	33%	33%	0%	33%	100%	0%	0%	0%
Bifacial	1	100%	100%	0%	100%	100%	0%	100%	100%	0%	0%	0%
Bipolar	1	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
indeterminate	3	67%	33%	0%	33%	33%	0%	33%	100%	0%	0%	0%
Lower Occupation			Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grind	Edge Crush	Edge Flake	Surface Grind	Surface Crush	Surface Flake	Yes	Maybe	No	N/A
All	89	70%	53%	2%	24%	35%	10%	44%	78%	2%	9%	7%
Amorphous	19	68%	53%	0%	5%	32%	11%	37%	74%	5%	21%	0%
Bifacial	33	91%	82%	0%	45%	48%	0%	58%	91%	0%	3%	6%
Bipolar	17	82%	41%	12%	6%	41%	35%	59%	76%	6%	6%	12%
Indeterminate	11	36%	27%	0%	36%	18%	0%	27%	73%	0%	9%	18%

Metrics were recorded for all of the cores to infer the nature of core reduction. Maximum length, width, thickness and weight were identified for each core. Descriptive statistics of these measurements are provided as Appendix 21. The descriptive statistics indicate that the upper occupation had larger, less reduced cores. Therefore, less intensive core reduction occurred in the upper occupation. The middle occupation had the smallest and most reduced cores. A middle size range was present in the lowest occupation. Clearly, this occupation had the greatest diversity and number of cores.

When the lower component cores were organized by size, the size order sequence, largest to smallest, was: tested cobbles, bipolar, amorphous, platform, bifacial, and indeterminate cores. Systematically, this size order made sense, where the largest cores indicate both the largest flake-blank production and/or earlier stages of reduction. The large size of bipolar cores supported the use of bipolar techniques to create large flake blanks.

From the rediscovery of thermal alteration by Don Crabtree (Crabtree and Butler, 1964), there has been the prevalent assumption that only preforms or large flakes were thermally altered (Leudtke 1992:92). At Below Forks, entire cores were thermally treated before significant knapping occurred. Interestingly, the tested cobbles were not thermally altered, while most of the other core types were. The assemblage suggests that items were sometimes tested for material type, used as is, or set aside for alteration. The thermal alteration of entire cores of SRC has been noted from sites in Minnesota by Bakken (1995).

The analysis of cores was a very important part in elucidating the lithic technology. Not surprising, the recovery of many cores reinforces that Below Forks was a workshop and habitation site. Platform preparations occurred on about half of the cores, where platform surface grinding, and exterior platform edge grinding were most important. The edge and surface flaking of platforms did occur. Three core reduction strategies are indicated in the lower occupation: a bipolar, bifacial and amorphous strategy. Each have a distinct complex of platform preparations. The thermal alteration of entire cores was common, such that 78 % of the cores were altered.

6. 3 Red Ochre.

Red ochre was present at the Below Forks site. Ochre over antiquity has an obvious ceremonial importance. Minerals were recovered as hard pebble nodules of non-greasy hematite. These iron rich rocks were the northern equivalent to ochre. Ochre (n=56) was mainly present in the lower occupation of the site, weighing a total of 37.2 g. As well, soil discolourations from ochre were identified in the lower occupation. A single piece of ochre was present in the middle occupation. This presence of ochre may have related to soil development or cultural mechanisms. Although not certain, the ochre was likely of cultural significance. The nearest known ochre source is situated 10 kilometres downstream from Prince Albert, in an exposure in the North Saskatchewan river valley. (Saskatchewan Department of Natural Resources 1938). Other exposures of ochre might be present in the region of the confluence of the Saskatchewan rivers. Thus ochre was regionally available. To conclude, ochre was present in the lower occupation.

6.4 Fire Cracked Rock.

Fire cracked rocks were composed of a variety of materials. Table 6.4 presents a summary of the FCR present in each occupation. Fire cracked rock was more abundant in the lower occupation, somewhat present in the middle occupation and sparse in the upper occupation. In the upper occupation, igneous and metamorphic rocks were preferred for FCR. In the middle and lower occupation, igneous and sedimentary rocks were preferred. Sedimentary rocks were predominately limestone; igneous rocks were represented by granite and basalt; metamorphic rocks were of schist and gneiss. All rocks were locally available as river cobbles. The presence of FCR indicate water boiling and related roasting of organic materials (Brink and Dawe 1989; Frison 1983; Frison 1991:355-356; Lovick 1983). The FCR present within the site was unrelated to any thermal alteration feature.

Table 6.4. Summary of fire cracked rock.

Fire Cracked Rock	Frequency				Weight			
Occupation	Igneous	Metamorphic	Sedimentary	Total	Igneous	Metamorphic	Sedimentary	Total
Upper Occupation	13	5	1	19	139.8	170	29.1	338.9
Level 3	18	6	3	27	68.3	801.1	19.5	888.9
Middle Occupation	23	7	4	34	603.4	179.9	580.4	1363.7
Level 7	5	2	1	8	4	3.4	4.2	11.6
Lower Occupation	108	31	30	169	629.6	241.2	751.4	1622.2
Totals	167	51	39	257	1445.1	1395.6	1384.6	4225.3
FCR Percentage	Frequency				Weight			
Occupation	Igneous	Metamorphic	Sedimentary	Total	Igneous	Metamorphic	Sedimentary	Total
Upper Occupation	68%	26%	5%	19	41%	50%	9%	338.9
Level 3	67%	22%	11%	27	8%	90%	2%	888.9
Middle Occupation	68%	21%	12%	34	44%	13%	43%	1363.7
Level 7	63%	25%	13%	8	34%	29%	36%	11.6
Lower Occupation	64%	18%	18%	169	39%	15%	46%	1622.2
Totals	65%	20%	15%	257	34%	33%	33%	4225.3

6.5. Summary.

Chapter six contained the analysis of cores, ochre, and fire cracked rock. Core analysis expanded and confirmed inferences about lithic technology. Thermal alteration and platform preparation were an important component of core reduction. Distinct suites of preparation were noted for bifacial, bipolar and amorphous reduction strategies. Red ochre was present in the site as soil discolourations and as small hematite nodules. The presence of ochre was limited to the lower occupation, and indicates a ceremonial manifestation. Fire cracked rock was present in the site, but was not generally abundant. Its presence indicate that hearths were situated near the areas excavated. Unfortunately, hearth features were not uncovered in site excavations.

"*walking barefoot through spring forest*
mud, tangle brush and mottled leaf
feet plastered with messages"
Joy Kogawa (2003:116).

7. SPATIAL ANALYSIS AND INTERPRETATIONS.

7.1 Introduction.

A spatial analysis was conducted to further interpret the lithic technology of the Below Forks site. Excavation suggested that different lithic materials and technological types were clustered into distinct areas within a reduction workshop. For the following analysis, I follow Ferring's definitions of activity and activity areas:

> For the purposes of intrasite spatial analysis the fundamental behavioral construct proposed here is the activity defined as a specific task resulting in the deposition of diagnostic clustered archaeological remains (Ferring 1984:116).
>
> The spatial correlate of activity is the "activity area", defined as an archaeologically consistent, spatially clustered, association of artifacts and/or ecofacts in a minimally dated archaeological horizon (Ferring 1984:117).

Excavation suggested that activity areas were represented by artifact spatial patterning. In the eastern area, the upper and middle occupations were notably different from the lowest occupation. The upper occupation demonstrated early stage lithic reduction and some tool production through the association of cores, hammerstones, large decortication flakes, and few smaller items. The middle occupation appeared peripherial to a habitation site since cultural materials in the component were sparse. It contained some large bone, FCR, and very little debitage. Both the upper and middle components presented a configuration that definitely contrasted with the greater density and variety of debitage in the lower occupation. Dense knapping locales with nearby habitation debris were evident in the lower occupation. Notably, an association of many bipolar flakes were recovered near an anvil.

Features were identified from both the middle and lower occupations. The basic spatial patterning of each component were further described on contour density plots. These plots were then statistically assessed with the Moran I (Moran 1948) and Geary

C (Geary 1954) autocorrelation tests, following the Cliff and Ord (1981) methodology. Then, similarities and differences between artifact classes were identified with Pearson's product moment, from Alvi (1995:143-147), and the Spearman's rank order correlation coefficients, also from Alvi (1995:150-151). Lithic technology served as the focus of the spatial analysis of the eastern area of Below Forks.

7.2 Below Forks Features.

One feature was present in the middle occupation, and nine features were exposed in the lower occupation, as summarized on Table 7.1. The middle occupation had an oval pit filled with burned bone and FCR, and was associated with reddened silt. Identifiable faunal remains from the feature include a beaver mandible. This feature does not appear to have been a hearth, but likely was a disposal of hearth refuse.

Table 7.1. Features of the Below Forks site.

Feature Number	Occupation	Feature Type	Location	Depth in cm.
1	Middle	Oval Pit Filled with FCR and Burned Bone	88N212E	35-45
1	Lower	Major Flake Concentration	89N213E	92-100
2	Lower	Small Flake Concentration	87N212E	93-99
3	Lower	Small Flake Concentration	90N211E	92-96
4	Lower	Moderate Flake Concentration	90N209E	92-100
5	Lower	Moderate Flake Concentration	89N218E	90-100
6	Lower	Burned Bone Pit	89N213E	101-107
7	Lower	Red Ochre Stain	90N210E	95-99
8	Lower	Red Ochre Stain	90N210E	100-110
9	Lower	Red Ochre Stain	90N211/212E	95-99

Figure 7.1 indicates the spatial extent of features as recorded on the level planview forms. To clarify, the flake concentrations were mapped on planviews after a significant amount of debitage, often over 200 items, were point provenienced. Thus, the flake concentrations, as mapped, represent the densest areas and foci of lithic reduction. The most significant feature of the lower occupation was a major flake concentration in 89N 213E, called feature 1. Two smaller and two moderate sized flake concentrations were present. All flake concentrations appear to have been *in-situ* knapping stations. A pit filled with burned bone was situated below feature 1. Red ochre soil discolourations

occurred in the northwestern portion of the excavation block. To conclude, the features indicate that activity areas were present, with lithic knapping being most significant.

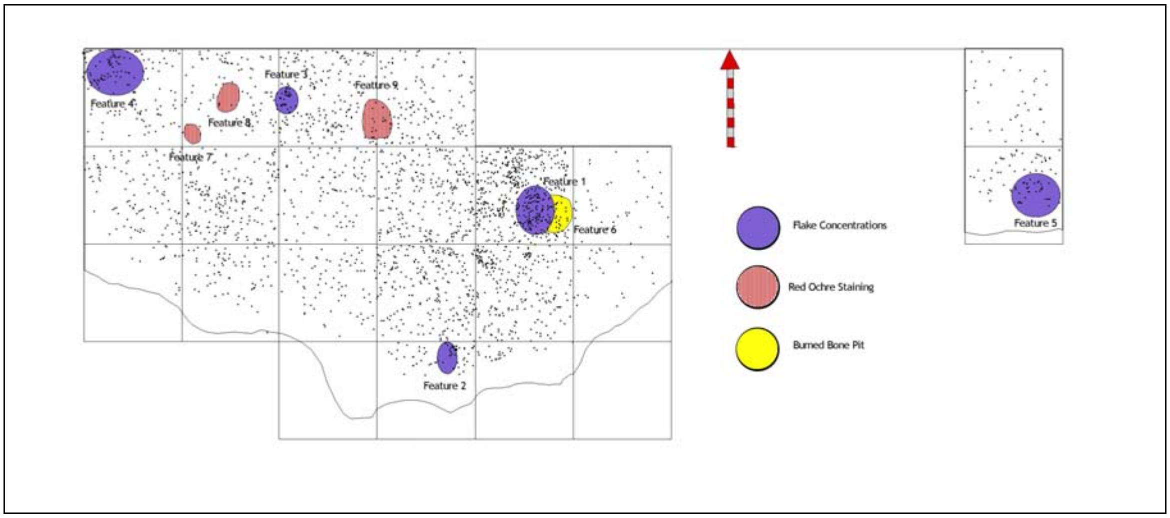


Figure 7.1 Features of the lower occupation, from planview record forms, including point provenienced artifact distribution.

7.3 Contour Density Plots.

7.3.1 Introduction to Contour Density Plots.

Contour density maps were created for various artifact classes based on quadrant summaries. All contour density plots were created on *ArcView 3.2*, with the *Spatial Analysis* extension. Point provenience data were not used since it was difficult to incorporate point and quad data into a statistical analysis. The spatial distibution of point provenienced items were biased as the size of artifacts provenienced varied by excavator. The movement of artifacts from their original poistion by rodent disturbance confounded the spatial bias. Quad summaries provided an effective means of avoiding bias. Contour density plots are common in the archaeological literature (Bang-Anderson 2003; Crombé et al. 2003; Ellis and Deller 2000:151-193; Johnson 1984:90-91; Loeffler 2003; Overstreet 1993:53). The methods of contour density plot manufacture and analysis are best summarized in Whallon (1984:242-277).

Point provenience was worthwhile as the three dimensional constructs presented in chapter three are based on point provenience data. After experimenting with contour density maps based on point provenience data I observed that these maps were often incorrect. The GIS would interpolate across sterile areas, create false centres, and often ignored information if multiple artifacts occupied the same two dimensional position. In this situation the GIS included the first artifact in the series in the contour density plot, and ignored the rest. Thus, for the contour density plots and subsequent statistical analyses based on these contour density plots, point provenience data were inappropriate. Point provenience data are better utilized in a three dimensional environment where the information can assess context and delineate three dimensional features (Nelson et al. 1987; Spikins et al. 2002). A second problem of the site spatial analysis was that point provenience and quadrant summaries could not be integrated together. Every provenience item had a frequency of one, while the contents of every quadrant bag regularly had a much larger frequency. The GIS did not distinguish between point and quadrant data in a contour density plot. In this situation, the outcome was a bulls-eye around the centre of each quad and an even surface, with a value of one, surrounding the bulls-eyes. A solution to this problem was to include point provenienced artifacts in corresponding quadrant frequencies, and then create contour density plots based on corrected quadrant summaries.

A significant problem of the spatial analysis was the quadrant summary table. All provenienced and small finds bags were converted into quadrant centred locations. This process lost a degree of spatial information. An additional problem was that absence of information was not taken into account in the GIS spatial analysis. If there was a known grid with sterile gaps in it, the GIS interpolated values between the grid points to produce a false concentration onto sterile areas. A method to compensate was to plant known null values for sterile quads. The sterile quad problem must be compensated for in a spatial analysis on *ArcView*. On the whole, contour density maps were simple and expedient to create with *ArcView 3.2*. Importantly, analytical problems like incorporating point and quadrant data sets must be addressed for a valid spatial analysis.

7.3.2 Contour Density Plot of the Upper Occupation.

In the upper occupation, spatial distribution was relatively limited due to the smaller area exposed as compared to the other occupations. The important contour density plots are illustrated on Figure 7.2. Other contour density plots of the upper occupation are located in Appendix 23.1. There was a correspondence between cores, debitage, flakes, shatter and FCR in the northwestern corner of the excavation block.

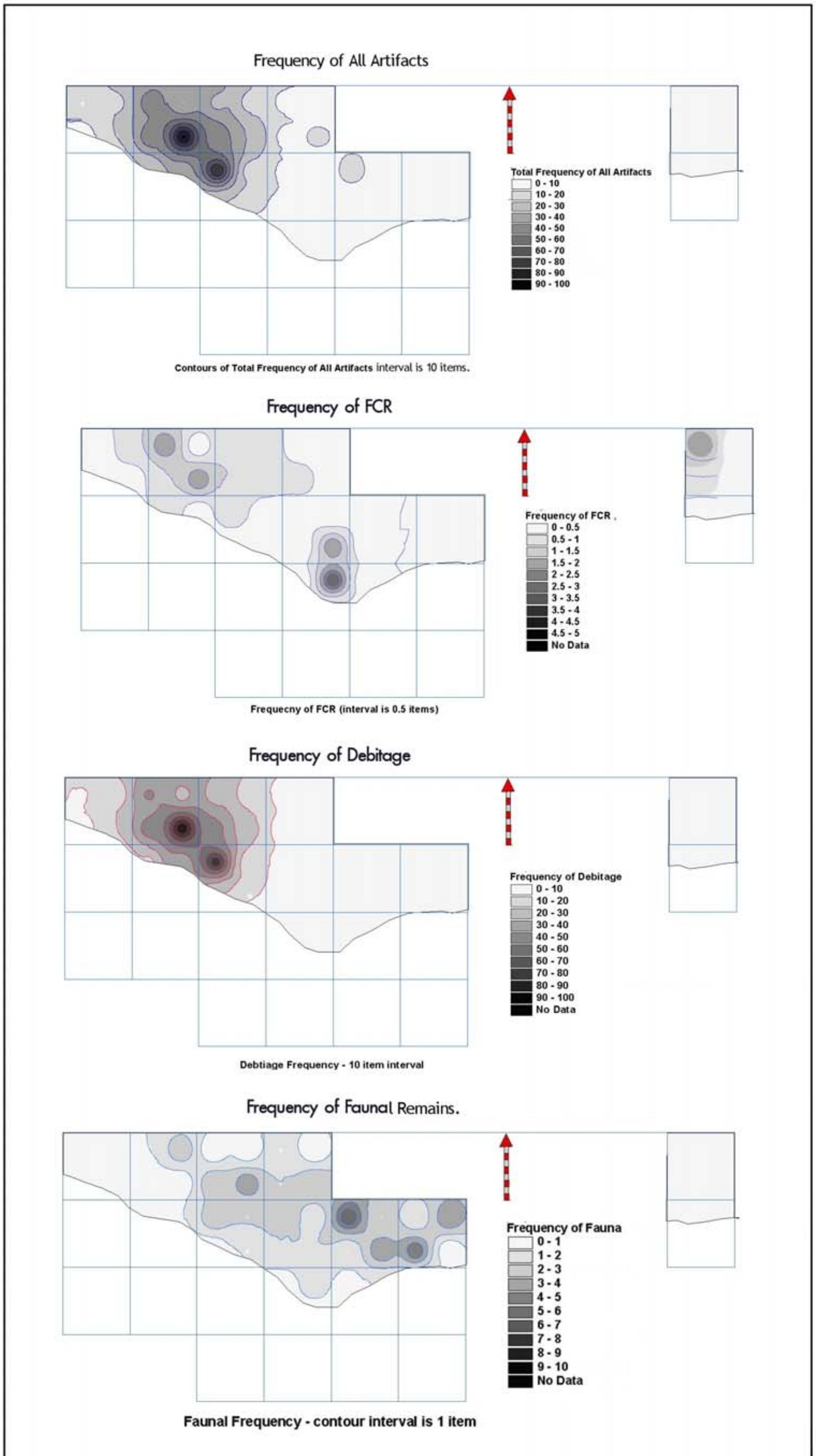


Figure 7.2. Contour density plots of the upper occupation

Cores were situated near, but not directly with debitage. Faunal remains were spatially separate and occurred in the eastern area of the block. Notably, more raw bone was present than burned bone. There were no significant differences between distributions based on artifact frequency or weight, a pattern suggestive of more complete (less fragmented) artifacts. The overall spatial distribution indicated that a lithic reduction station was situated in the northwestern corner, while household faunal debris was scattered to the east.

7.3.3 Contour Density Plots of the Middle Occupation.

Artifact recoveries from the middle occupation were sparse, which limited the spatial analysis. An association of FCR, fauna and burned bone was present in the centre of the block. Figure 7.3 illustrates the co-occurance of these materials. Fire cracked rock occurred in the northwestern corner and a moderate amount was present in the northeastern corner of the excavation (218E unit). Cores were mainly distributed in the east-centre of the block, while one core was situated in the northwestern corner. The distribution of cores, shatter and debitage are presented as Appendix 23.2. There was a concentration of shatter in the southeastern corner of the excavation. Cores and shatter co-occurred spatially, and both were separated from the debitage. A wide distribution of flakes occured and had a northeastern foci. The general loci of occupational materials was in 88N212E. In a similar situation, Bodu (1998:134-138) discussed the nature of spatial loci, how they were identified and their importance for site interpretations. Overall, the material distribution related to a general scatter of habitation site materials. An important feature of burned bone and FCR presented a spatial focus of the occupation.

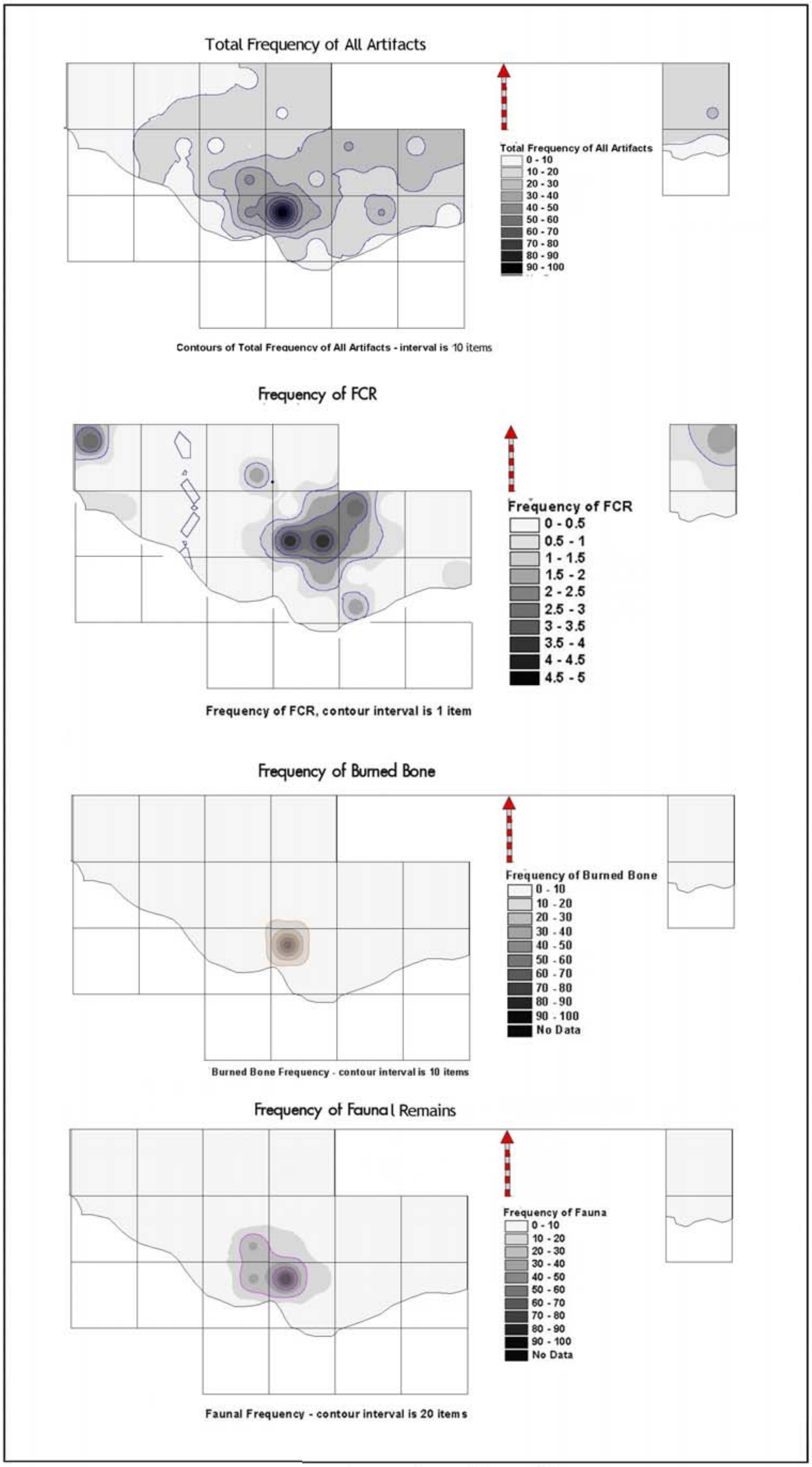


Figure 7.3. Contour density plots of the middle occupation.

7.3.4 Contour Density Plots of the Lower Occupation.

Spatial patterning was indicated by the lower occupation contour density plots. There was a correspondence between burned bone and the major knapping feature. The frequency of flakes accurately described flake concentrations mapped during excavation. Cores were not situated in the flake concentrations, but instead occurred outside of the flake concentrations. There was some suggestion of a distinct core discard pattern, which was statistically testable. The greatest concentration of shatter was in the area of the main flaking station. However, shatter had a wide distribution that likely related to proximity to the anvil and a resultant greater spread of debris from bipolar and hard hammer percussion. Figure 7.4 presents the distributions of flakes, cores, shatter and total artifacts from the lower occupation. A wide distribution of FCR was present, suggestive of a cleaned-out hearth feature. Interestingly, the greatest concentration of FCR was near, but not directly associated with burned bone. A pit filled with charred remains was identified by the central cluster of burned bone. This burned bone feature was overprinted by a knapping station. The far eastern units (89 and 90N, 218E) were difficult to interpret spatially as they represented a small portion of a larger spatial pattern. These units showed in-situ knapping, with superimposed concentrations of all other artifact classes, and are best interpreted as a midden deposit.

Spatial patterning of the lower occupation indicated areas of red ochre use, individual knapping features and the proximity of a hearth. Hematite fragments and soil discolourations indicated red ochre use, and was unassociated with flake concentrations. Therefore, red ochre use was peripheral to knapping areas. The distribution of burned bone, FCR and the regionally available materials are illustrated on Figure 7.5. Other contour density plots are included as Appendices 23.3 to 23.6. There was no direct evidence of a hearth, but given the amounts of FCR and burned bone, one evidently was nearby. Gronlid siltstone and Red Willow silicified sandstone were located in the same area. Since regionally available materials were of reduced quantities, individual knapping activities were identified. Quartz had wide dispersal, with clustering near the anvil, suggestive of bipolar reduction. Quartzite was utilized in the major knapping area. The silicified wood was isolated, and related to a small area of tool manufacture. Siltstone was associated with knapping locale features 1 and 3.

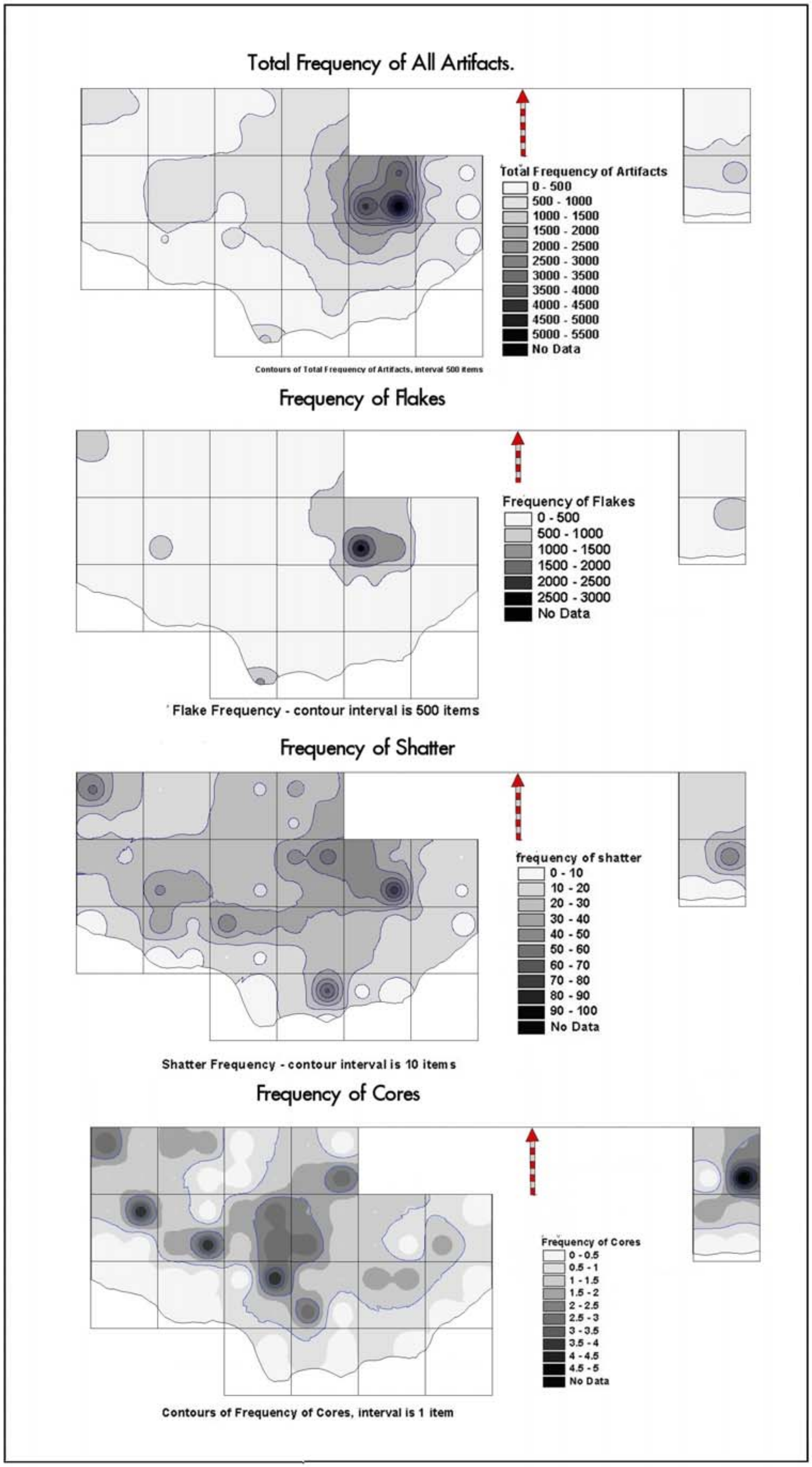


Figure 7.4. Contour density plots of the lower occupation, part one.

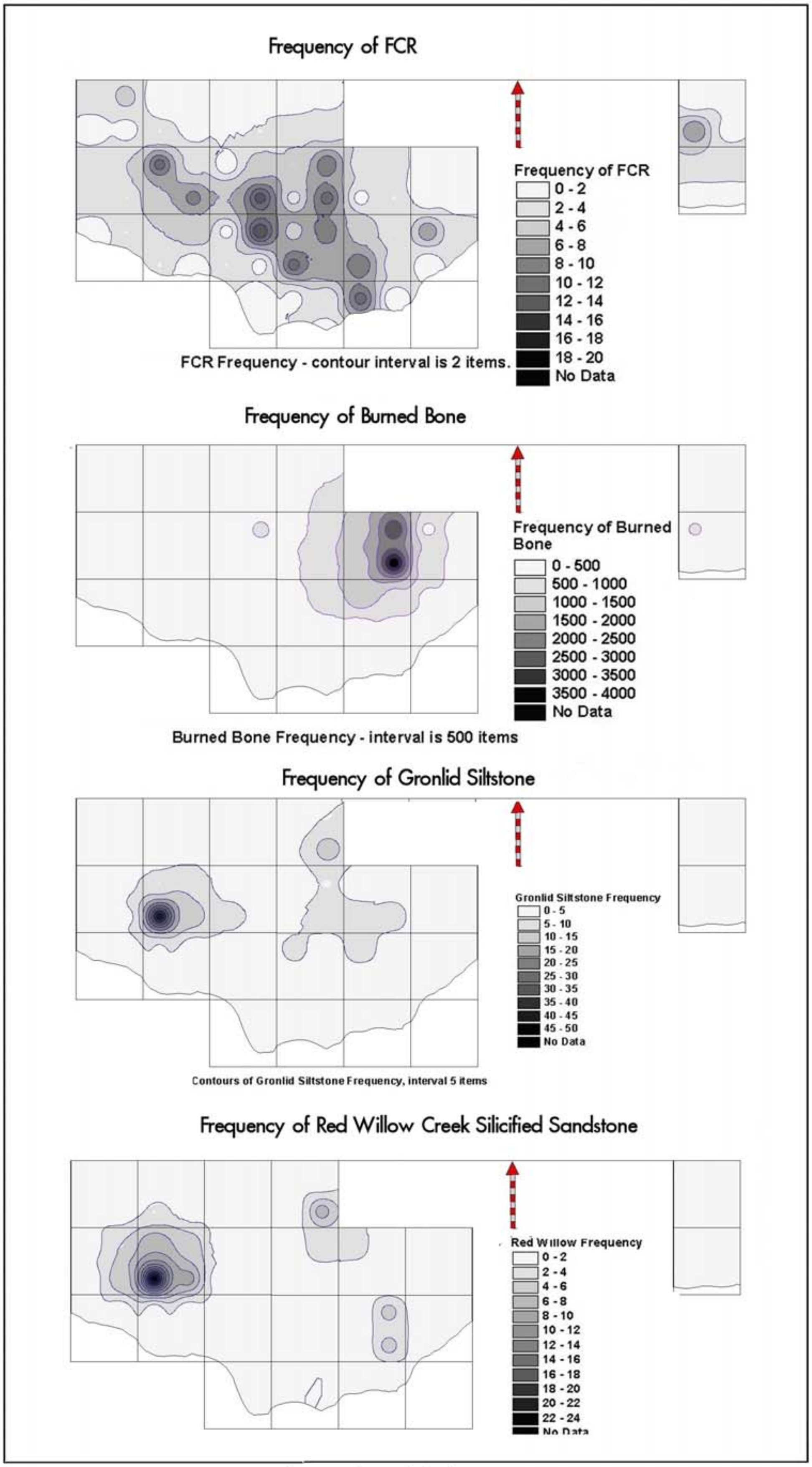


Figure 7.5. Contour density plots of the lower occupation, part two.

Microdebitage overabundance based on frequency obscured the complexity of debitage distribution and simplified patterning to indicate areas of late reduction stages. On the other hand, distibutions based on weight were biased towards earlier stage reduction, especially with regard to cores. This problem was obvious on the total weight summary density plot. The contour density maps described clustering and dispersal, but the *intensity* of concentration was indicated on the map scale. A degree of mixing and overprinting were a warning not to over-interpret the spatial patterning of the lower occupation.

7.4 Spatial Autocorrelations.

Statistical methods were undertaken to address the nature of spatial distribution. These statistics provide description of spatial autocorrelation, which is the way similar items are located near one another (Goodchild 1986:3; Tobler 1974). Spatial autocorrelation tests identify random, normal or clustered distributions for a single artifact class (Gladfetter and Tiedemann 1985:457). Autocorrelation statistics are important since they are a means to separate natural (random) versus cultural (clustered) phenomena and indicate the spatial nature of refuse disposal and dispersion (Wheatley and Gillings 2002:130-134). The statistics chosen were the Moran I and Geary C statistics, the two main autocorrelatation tests used for archaeological analysis (Cliff and Ord 1981:13-17, Hodder and Orton 1976:181-184). Moran I and Geary C are well known in the archaeological literature (Bertorelle and Barbujani 1995; Chikhi et al. 1998; Fuselli et al 2003; Kvamme 1990, 1996; Whitley and Clark 1985).

The Moran I and Geary C statistics were interpreted with *Spatial Statistics Version 1.0* extention for *ArcView 3.2* (Esri 2003a). Spatial autocorrelations were not possible for the upper and middle occupations due to small sample size. When attempted, the Moran I and Geary C statistics were returned as null values. The spatial autocorrelations of the lower occupation were successful due to a greater sample size. Moran I and Geary C are very complex statistical analyses, their equations are included as Appendix 26, based on Gladfetter and Tiedemann (1985:496-500).

7.4.1 Pattern Recognition of Moran I and Geary C Statistics.

A guide is included for the interpretion of autocorrelation statistics. Tables 7.2 and 7.3 illustrate the meaning of the statistics. As Moran I approaches 1, a strong positive autocorrelation is indicated; as it approaches -1, strong negative autocorrelation is described (Goodchild 1986:5). A random distribution is identified as Moran I approaches -1/(n-1), where n is the number of analysis cells (Cliff and Ord 1981:13-17). As Geary C approaches 0 , strong postive autocorrelation is indicated, as it approaces 2, a strong negative autocorretion is described. As it approaches 1, a random distribution is identified (Cliff and Ord 1981:13-17, Vasiliev 1996:27).

Table 7.2. Moran I and Geary C pattern recognition, based on Cliff and Ord (1981-13-17), and Goodchild (1986:3).

Pattern Recognition	Moran I	Geary C
Similar, regionalized Smooth Clustered	I>0	0<C<1
Independent, Uncorrelated Random	I<0	C=1
Dissimilar Contrasting Checkerboard	I<0	C>1

Table 7.3. Examples of autocorrelation patterning.

Moran I	Geary C	Pattern
I ~ 0.25	C ~ 0.65	Bulls-eye Pattern
I ~ 0.9	C ~ 0.24	Edge Concentration
I ~ -0.5	C ~ 1.75	Checkerboard

7.4.2 Lower Occupation Autocorrelation Results.

The results of the Geary C and Moran I tests of the lower occupation were included as Tables 7.4 and 7.5. The autocorrelations indicated that the majority of artifact classes were strongly autocorrelated. Most materials were clustered, while some were more localized than others. Of note were Geary C values at, or near 0, these show perfect positive autocorrelations, and indicate that the spatial data were not random nor normal (see Appendix 27). Only the 'all decortication flakes' category provided a random autocorrelation. In hindsight this related to the lumping together of disparate distributions of primary, secondary, and tertiary decortication flakes. Individually the decortication flake types were strongly autocorrelated. There was a general concordance between autocorrelations based on frequency and weight. Minor differences occurred, and were related to fragmentation processes (e.g. FCR). The distribution of materials represented cultural patterning.

Table 7.4 Autocorrelation of lower occupation by frequency.

Frequency	Moran's I	Geary's C	Pattern
FCR	-1.225	2.459	Dissimilar, Contrasting.
Debitage	0.665	0.016	Clustered
Flakes	0.629	0.012	Clustered
Shatter	1.013	0.255	Edge Concentration
Faunal Remains	0.309	0.000	Clustered
Burned Bone	0.263	0.000	Clustered
Cores	0.892	0.000	Clustered
Total items	0.547	0.004	Clustered
Ochre	Null	Null	Not Applicable
Siltstone	0.251	0.000	Clustered
Gronlid siltstone	0.150	0.017	Clustered
Red Willow	0.037	0.050	Clustered
Quartz	Null	Null	Not Applicable
Silicified Wood	0.062	0.000	Clustered
Quartzite	0.116	0.000	Clustered
Medial Portions	0.929	0.000	Clustered
Proximal Portions	1.143	0.112	Clustered
Distal Portions	Null	Null	Not Applicable
All Broken Flakes	0.407	0.075	Clustered
Split Flakes	0.493	0.641	Regional Intensity with Dispersal
Primary Decort.	0.063	0.000	Clustered - Single Bulls-eye with Outliers
Secondary Decort.	0.453	0.000	Clustered with Multiple Bulls-eyes.
Tertiary Decort.	-1.233	3.217	Dissimilar, Contrasting.
All Decort.	-0.639	1.276	Random
Bipolar	0.178	0.000	Clustered
Shaping	-1.241	2.490	Dissimilar, Contrasting.
Bifacial-reduction	0.539	0.107	Clustered
Hard Hammer	0.473	0.468	Core Clusters with Wide Dispersal
Soft Hammer	0.576	0.298	Regional Intensity with Dispersal
Heated SRC	1.125	0.014	Clustered

Table 7.5. Autocorrelation of lower occupation by weight.

Weight	Moran's I	Geary's C	Pattern
FCR	0.110	0.022	Clustered
Debitage	0.232	0.029	Clustered with Bulls-eye
Flakes	0.183	0.009	Clustered with Bulls-eye
Shatter	0.386	0.438	Clustered
Faunal Remains	0.412	0.000	Clustered
Burned Bone	0.263	0.000	Clustered with Bulls-eye
Cores	0.500	0.000	Clustered
Total items	0.547	0.004	Clustered
Ochre	Null	Null	Not Applicable
Siltstone	0.251	0.000	Clustered
Gronlid siltstone	0.345	0.000	Clustered
Red Willow	0.037	0.050	Clustered
Quartz	Null	Null	Not Applicable
Silicified Wood	0.033	0.000	Clustered
Quartzite	0.166	0.000	Clustered
Medial Portions	0.747	0.000	Edge Concentration
Proximal Portions	0.252	0.074	Clustered
Distal Portions	Null	Null	Not Applicable
All Broken Flakes	0.542	0.073	Clustered
Split Flakes	0.510	0.110	Localized Clusters
Primary Decort.	0.063	0.000	Clustered
Secondary Decort.	0.453	0.000	Clustered
Tertiary Decort.	-0.323	0.715	Contrasting, Partly like a Checkerboard.
All Decort.	-0.639	1.276	Random
Bipolar	0.122	0.000	Clustered
Shaping	-0.965	1.919	Dissimilar, Contrasting
Bifacial-reduction	0.315	0.131	Clustered with Multiple Bulls-eyes
Hard Hammer	0.473	0.468	Core Clusters with Wide Dispersal
Soft Hammer	0.089	0.595	Regionalized Bulls-eye
Heated SRC	1.125	0.014	Clustered

7.5 Correlation Coefficients.

The nature of distributional similarity are tested with the Pearson's product moment and Spearman's rank order correlation coefficients. These two methods are used to mutually assess their validity. Co-occurance statistics are known in the archaeological literature (Gibson 2001; Johnson 1984:90-91; Rankama 1997:51-139). Equations of Pearson's R and Spearman's rank order are provided as Appendices 24 and 25, based on Alvi (1995:141-155). Both the upper and middle occupations had sample sizes too small for valid statistical tests, and therefore are excluded from the following discussions. The Pearson's product moment correlation coefficient was executed on the *Gstats* extension for *ArcView3.2* (Esri 2003b). Spearman's rank order correlation coeffient was assessed in *Microsoft Excel 2000*. Correlation coefficient statistics always are a value between -1 and 1, where -1 represents a perfect negative correlation and 1 represents a perfect positive correlation. Values around 0 indicate that no correlation was detected between the two variables studied. The correlation coefficients were conducted on both the frequency and weight of artifact classes. Both the upper and middle occupations had sample sizes too small for valid correlation tests.

7.5.1 Pearson's R Product Moment Coefficient.

The distribution by frequency and weight of various artifact classes from the lower occupation were analyzed with the Pearson's product moment correlation coefficient and are summarized on Tables 7.7 and 7.8. Positive correlations were indicated when the Pearson's R statistic was greater than 0.7. A lack of correlation was indicated with values from -0.2 to 0.2. Table 7.6 presents the important correlations detected with this method. On the whole, the statistic confirmed distinctly related artifact types and indicated to some degreee the absence of correspondence. A notable co-occurance of Red Willow Creek silificied sandstone and Gronlid siltstone occurred. Also of importance was the separation of FCR from all other artifact types. Contrary to expectation, there was a lack of correspondence between cores to debitage, and cores to decortication flakes. The correlation results by weight were similar to correlations by frequency, though the intesity of the correlations varied. In conclusion the Pearson's R was of limited use in the identification of inter-relationships between artifact categories.

Table 7.6. Important Pearson's R correlations by frequency of various artifact classes.

Artifact Type	Relationship	Artifact Type(s)
Total Artifacts	+ relationship to	Debitage, Flakes, Faunal Remains, and Burned Bone.
Debitage	+ relationship to	Flakes
Shatter	+ relationship to	Heated SRC
Faunal Remains	+ relationship to	Burned Bone
Red Willow Creek	+ relationship to	Gronlid siltstone
Proximal Portions	+ relationship to	Hard Hammer, Soft Hammer, Heated SRC
Hard Hammer	+ relationship to	Split flake portions, Soft Hammer, Heated SRC
Cores	* unrelated to	Debitage, Decortication Flakes
FCR	* unrelated to	All Artifact Types
SRC	* unrelated to	All Other Lithic Material Types.
Decortication	* unrelated to	All Broken Flake Portions (Prx, Med, Dist, Split)
Bipolar	* unrelated to	All Artifact Types

+ relationship, indicates that a positive correlation was detected.
** unrelated,* indicates that no correlation was deteched.

Table 7.7. Pearson's R correlation coefficient, based on frequency.

	FCR	Debitage	Flakes	Shatter	Fauna	Burned I	Cores	Total Ite	Ochre	Siltstone	Gronlid	Red Will	Quartz	Silified V	Quartzite	Medial F	Proxima	Distal P	All Broke	Split	Primary	Second	Tertiary	All Deco	Bipolar	Shaping	Bi-Redu	Hard Ha	Soft Har	H-SRC
FCR	1.000																													
Debitag	0.046	1.000																												
Flakes	0.036	0.999	1.000																											
Shatter	0.258	0.636	0.611	1.000																										
Fauna	0.094	0.537	0.530	0.500	1.000																									
Burned	0.073	0.532	0.526	0.486	0.998	1.000																								
Cores	0.307	0.060	0.054	0.162	0.058	0.046	1.000																							
Total	0.090	0.806	0.801	0.624	0.932	0.929	0.068	1.000																						
Ochre	Null	Null	Null	Null	Null	Null	Null	Null	1.000																					
Siltstone	-0.220	0.595	0.599	0.266	0.125	0.121	0.065	0.342	Null	1.000																				
Gronlid	0.245	0.293	0.286	0.348	0.208	0.184	0.217	0.272	Null	0.081	1.000																			
Red Wil	0.186	0.162	0.157	0.232	-0.004	-0.021	0.246	0.068	Null	-0.034	0.839	1.000																		
Quartz	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	1.000																	
Silicified	0.094	-0.026	-0.032	0.130	-0.009	-0.013	-0.058	-0.017	Null	-0.125	-0.031	-0.075	Null	1.000																
Quartzit	0.051	0.320	0.316	0.310	0.216	0.220	0.092	0.289	Null	0.214	0.025	-0.062	Null	-0.045	1.000															
Medial F	-0.085	0.397	0.386	0.501	0.298	0.294	0.047	0.379	Null	0.556	-0.039	-0.042	Null	-0.158	0.236	1.000														
Proxima	0.231	0.585	0.567	0.791	0.427	0.416	0.296	0.552	Null	0.345	0.284	0.272	Null	0.012	0.274	0.624	1.000													
Distal P	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	1.000												
All Brok	0.108	0.407	0.394	0.550	0.288	0.285	0.234	0.377	Null	0.361	0.080	0.056	Null	0.048	0.560	0.455	0.653	Null	1.000											
Split	0.264	0.631	0.619	0.670	0.485	0.476	0.231	0.612	Null	0.307	0.445	0.413	Null	0.125	0.173	0.360	0.691	Null	0.427	1.000										
Primary	-0.027	-0.046	-0.042	-0.120	-0.005	-0.007	0.128	-0.023	Null	0.009	-0.072	0.009	Null	0.018	-0.053	-0.003	0.065	Null	0.064	0.036	1.000									
Second	0.087	0.439	0.429	0.513	0.539	0.538	0.020	0.566	Null	0.074	0.081	-0.037	Null	0.012	0.070	0.323	0.448	Null	0.191	0.521	0.084	1.000								
Tertiary	0.232	0.018	0.016	0.061	0.158	0.149	0.084	0.119	Null	-0.108	0.172	0.231	Null	0.157	0.081	0.061	0.211	Null	0.104	0.264	0.030	0.090	1.000							
All Deco	0.184	0.238	0.232	0.275	0.398	0.391	0.118	0.382	Null	-0.023	0.123	0.128	Null	0.113	0.068	0.218	0.410	Null	0.198	0.472	0.482	0.650	0.692	1.000						
Bipolar	0.129	0.045	0.042	0.106	0.073	0.062	0.229	0.071	Null	0.028	0.017	0.018	Null	-0.105	-0.013	0.131	0.075	Null	0.114	0.051	-0.020	0.036	-0.131	-0.071	1.000					
Shaping	0.420	0.140	0.130	0.307	0.258	0.241	0.157	0.242	Null	-0.143	0.241	0.206	Null	0.278	0.037	-0.137	0.231	Null	0.201	0.450	0.103	0.205	0.238	0.307	0.145	1.000				
Bi-Redu	0.245	0.250	0.237	0.447	0.242	0.241	0.097	0.278	Null	0.064	0.085	0.051	Null	0.368	0.071	0.112	0.351	Null	0.237	0.387	0.005	0.203	0.169	0.222	0.083	0.309	1.000			
Hard Ha	0.149	0.535	0.521	0.669	0.505	0.494	0.262	0.584	Null	0.371	0.366	0.317	Null	0.028	0.270	0.573	0.892	Null	0.626	0.745	0.094	0.459	0.347	0.514	0.023	0.339	0.332	1.000		
Soft Har	0.311	0.555	0.544	0.620	0.454	0.436	0.288	0.558	Null	0.177	0.361	0.369	Null	0.115	0.195	0.326	0.761	Null	0.414	0.718	0.095	0.418	0.263	0.439	0.203	0.551	0.510	0.719	1.000	
Heated	0.147	0.621	0.608	0.696	0.359	0.350	0.254	0.519	Null	0.541	0.217	0.204	Null	-0.075	0.443	0.674	0.804	Null	0.690	0.600	-0.013	0.336	0.128	0.263	0.089	0.088	0.314	0.764	0.640	1.000
	General Types									Material						Flake Portion					Decortation				Flake Type			Other		

represents no correlation detected
values between -0.2 and 0.2

represents strong positive correlation
values greater than 0.7

Table 7.8. Pearson's R correlation coefficient, based on weight.

	FCR	Debitage	Flakes	Shatter	Fauna	Burned I	Cores	Total Ite	Ochre	Siltstone	Gronlid	Red Will	Quartz	Silified V	Quartzit	Medial F	Proxima	Distal P	All Broke	Split	Primary	Second	Tertiary	All Deco	Bipolar	Shaping	Bi-Redu	Hard Ha	Soft Har	Heated S
	General Types									Material						Flake Portion					Decortation				Flake Type			Other		
FCR	1.000																													
Debitag	0.010	1.000																												
Flakes	-0.008	0.995	1.000																											
Shatter	0.141	0.633	0.551	1.000																										
Fauna	0.103	0.440	0.438	0.275	1.000																									
Burned	0.113	0.719	0.719	0.430	0.605	1.000																								
Cores	0.017	0.034	0.007	0.224	-0.077	0.035	1.000																							
Total	0.417	0.885	0.873	0.611	0.631	0.750	0.013	1.000																						
Ochre	Null	Null	Null	Null	Null	Null	Null	Null	1.000																					
Siltston	-0.112	0.073	0.069	0.074	0.028	0.104	0.017	0.021	Null	1.000																				
Gronlid	0.415	0.140	0.129	0.167	0.214	0.190	-0.112	0.321	Null	-0.103	1.000																			
Red Wil	0.014	-0.001	-0.032	0.233	-0.010	0.180	0.021	0.002	Null	-0.005	0.148	1.000																		
Quartz	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	1.000																	
Silicified	-0.030	0.038	0.040	0.007	0.043	-0.020	0.034	0.029	Null	-0.077	-0.045	0.083	Null	1.000																
Quartzit	-0.044	0.161	0.014	0.230	0.297	0.109	0.155	0.216	Null	-0.001	-0.007	0.088	Null	0.557	1.000															
Medial F	-0.006	0.376	0.342	0.484	0.140	0.320	0.058	0.322	Null	0.313	-0.011	0.258	Null	-0.108	0.068	1.000														
Proxima	0.074	0.437	0.395	0.582	0.134	0.288	0.338	0.399	Null	0.064	-0.008	0.066	Null	0.224	0.513	0.392	1.000													
Distal P	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	Null	1.000												
All Broke	0.094	0.471	0.426	0.621	0.118	0.285	0.322	0.428	Null	0.042	0.037	0.047	Null	0.217	0.484	0.395	0.954	Null	1.000											
Split	0.144	0.580	0.571	0.406	0.367	0.610	0.133	0.594	Null	0.016	0.111	0.128	Null	-0.035	0.134	0.280	0.196	Null	0.241	1.000										
Primary	-0.015	0.011	0.010	0.011	0.050	0.073	0.125	0.015	Null	-0.009	-0.011	0.012	Null	0.020	0.102	0.108	0.051	Null	0.054	0.044	1.000									
Second	-0.045	0.033	0.341	0.099	0.085	0.224	-0.046	0.257	Null	-0.030	0.046	0.019	Null	0.317	0.201	0.058	0.154	Null	0.209	0.309	0.008	1.000								
Tertiary	0.167	0.013	0.010	0.031	0.030	0.036	0.190	0.082	Null	-0.135	0.028	0.278	Null	-0.056	0.074	-0.007	0.045	Null	0.064	0.181	0.027	-0.048	1.000							
All Deco	0.030	0.307	0.317	0.105	0.095	0.227	0.052	0.272	Null	-0.087	0.163	0.139	Null	0.267	0.225	0.059	0.165	Null	0.223	0.366	0.104	0.895	0.394	1.000						
Bipolar	0.003	0.014	0.010	0.041	0.075	0.077	0.014	0.031	Null	-0.081	-0.043	0.013	Null	-0.630	-0.077	-0.012	0.041	Null	0.049	-0.008	-0.072	-0.087	-0.094	-0.126	1.000					
Shaping	0.144	0.413	0.404	0.312	0.254	0.234	-0.021	0.425	Null	-0.108	0.231	0.106	Null	0.015	0.003	0.089	0.193	Null	0.226	0.420	-0.038	0.155	0.160	0.208	-0.070	1.000				
Bi-Redu	0.312	0.208	0.177	0.363	0.190	0.282	0.030	0.328	Null	0.076	0.393	0.205	Null	0.060	-0.073	0.038	0.128	Null	0.152	0.163	0.074	0.046	0.152	0.115	-0.052	0.184	1.000			
Hard Ha	0.079	0.495	0.462	0.542	0.178	0.379	0.308	0.456	Null	-0.007	0.075	0.133	Null	0.245	0.472	0.361	0.895	Null	0.885	0.355	0.096	0.392	0.181	0.446	0.169	0.341	0.233	1.000		
Soft Har	0.127	0.452	0.422	0.493	0.307	0.464	0.045	0.474	Null	0.072	0.440	0.130	Null	0.088	0.232	0.242	0.370	Null	0.380	0.485	0.024	0.130	0.212	0.214	0.088	0.498	0.436	0.484	1.000	
Heated	0.099	0.567	0.523	0.667	0.251	0.455	0.298	0.537	Null	0.116	0.900	0.111	Null	0.114	0.396	0.527	0.867	Null	0.872	0.406	0.078	0.367	0.135	0.401	0.186	0.298	0.239	0.936	0.493	1.000

represents no correlation detected
values between -0.2 and 0.2

represents strong positive correlation
values greater than 0.7

7.5.2 Spearman's Rank Order Coefficient.

The distribution by frequency and weight of various artifact classes of the lower occupation of Below Forks were analyzed with the Spearman's rank order corrrelation coefficient, and the results are presented as Tables 7.11 and 7.12. Strong correlations between artifact types were present, indentified on statistic values greater than 0.7, non-correspondence was indicated for values less than 0.3 Important correlations are indicated on Tables 7.9 and 7.10.

Table 7.9. Important correlations from the Spearman's correlation coefficient by frequency.

Artifact Type	Relationship	Artifact Type(s)
Debitage	+ relationship to	Flakes, Shatter
Flakes	+ relationship to	Shatter
Faunal Remains	+ relationship to	Burned Bone
Red Willow	+ relationship to	Gronlid siltstone
Silicified Wood	+ relationship to	Quartz
Shatter	+ relationship to	All Broken Flake Portions.
Proximal Flake Portions.	+ relationship to	Total Broken Flakes, Distal Flake Portions, Split
Split	+ relationship to	Total Broken Flakes.
Total Broken Flakes	+ relationship to	Hard Hammer (strongly) and Soft Hammer (weakly)
Primary Decortication	+ relationship to	Secondary Decortication
Tertiary Decortication	+ relationship to	Total Decortication Flakes
Bipolar Reduction	+ relationship to	Total Decortication Flakes, Tertiary Flakes.
Hard Hammer	+ relationship to	Soft Hammer
FCR	- relationship to	Siltstone, Quartzite,
Total Decortication	- relationship to	Faunal Remains, Burned Bone, Quartz,
Bipolar Reduction	- relationship to	Faunal Remains, Burned Bone, Sil. Wood,
Bifacial Reduction	- relationship to	Quartz, Medial Flakes
Medial Flakes	- relationship to	Bifacial and Bipolar Reduction, Total Decort., FCR

+ relationship, indicates that a positive correlation was detected.
- relationship, indicates that a negative correlation was deteched.

Table 7.10. Important Spearman's statistic results by weight

Artifact Type	Relationship	Artifact Type(s)
Cores	*unrelated to	Decortication, Bipolar, Shaping
FCR	*unrelated to	Faunal Remains and Various Lithic Reduction Types

** unrelated,* indicates that no correlation was deteched.

Table 7.11. Spearman rank order correlation coefficient based on frequency

Freq.	FCR fr	Deb fr	Flakes	Shatter	Fauna	Burne	Cores	Total I	Ochre	siltstor	Gronli	Red W	Quartz	Silicife	Quartz	Media	Proxim	Distal(	Broker	Split(fr	Primar	Secon	Tertiar	All De	Bipola	Shapir	Bi-red	Hard H	Soft H	Heated
FCR(freq/ma	1.00	0.35	0.35	0.45	0.37	0.36	0.38	0.38	0.52	0.11	0.46	0.35	0.38	0.31	0.10	0.04	0.36	0.37	0.36	0.47	0.43	0.40	0.50	0.47	0.44	0.54	0.37	0.31	0.44	0.27
Debitage(fre	0.35	1.00	1.00	0.83	0.60	0.57	0.42	0.86	0.56	0.57	0.61	0.50	0.55	0.45	0.38	0.50	0.77	0.65	0.80	0.72	0.47	0.50	0.39	0.43	0.46	0.45	0.51	0.74	0.72	0.80
Flakes(freq/	0.35	1.00	1.00	0.81	0.59	0.56	0.42	0.85	0.56	0.57	0.61	0.49	0.56	0.44	0.38	0.51	0.76	0.64	0.79	0.72	0.47	0.51	0.40	0.44	0.46	0.45	0.50	0.75	0.73	0.80
Shatter(freq/	0.45	0.83	0.81	1.00	0.66	0.64	0.45	0.77	0.64	0.52	0.61	0.52	0.62	0.59	0.46	0.49	0.81	0.73	0.84	0.67	0.41	0.48	0.33	0.36	0.43	0.49	0.56	0.70	0.68	0.77
Faunal(freq/	0.37	0.60	0.59	0.66	1.00	0.99	0.68	0.89	0.62	0.43	0.62	0.50	0.60	0.51	0.56	0.46	0.58	0.54	0.59	0.53	0.46	0.38	0.23	0.25	0.29	0.41	0.41	0.60	0.62	0.59
Burned Bon	0.36	0.57	0.56	0.64	0.99	1.00	0.68	0.87	0.62	0.43	0.60	0.48	0.60	0.50	0.57	0.46	0.56	0.52	0.57	0.51	0.48	0.38	0.22	0.23	0.29	0.40	0.40	0.59	0.60	0.57
Cores(freq/n	0.38	0.42	0.42	0.45	0.68	0.68	1.00	0.61	0.51	0.44	0.52	0.54	0.59	0.49	0.45	0.36	0.52	0.49	0.51	0.51	0.49	0.38	0.29	0.32	0.37	0.37	0.33	0.53	0.55	0.53
Total Items	0.38	0.86	0.85	0.77	0.89	0.87	0.61	1.00	0.61	0.49	0.62	0.50	0.60	0.50	0.53	0.49	0.68	0.61	0.70	0.64	0.51	0.46	0.31	0.34	0.38	0.43	0.44	0.69	0.70	0.69
Ochre (freq/	0.52	0.56	0.56	0.64	0.62	0.62	0.51	0.61	1.00	0.54	0.56	0.55	0.59	0.46	0.38	0.33	0.55	0.51	0.55	0.60	0.53	0.48	0.38	0.39	0.43	0.58	0.43	0.51	0.70	0.56
Siltstone (fre	0.11	0.57	0.57	0.52	0.43	0.43	0.44	0.49	0.54	1.00	0.56	0.52	0.45	0.35	0.39	0.66	0.60	0.54	0.63	0.57	0.49	0.45	0.28	0.32	0.33	0.29	0.43	0.68	0.52	0.75
Gronlid Silts	0.46	0.61	0.61	0.61	0.62	0.60	0.52	0.62	0.56	0.56	1.00	0.76	0.54	0.42	0.42	0.32	0.61	0.55	0.62	0.60	0.45	0.47	0.34	0.36	0.36	0.60	0.44	0.66	0.68	0.63
Red Willow	0.35	0.50	0.49	0.52	0.50	0.48	0.54	0.50	0.55	0.52	0.76	1.00	0.56	0.41	0.30	0.39	0.58	0.36	0.56	0.63	0.47	0.45	0.35	0.39	0.32	0.52	0.41	0.59	0.67	0.58
Quartz	0.38	0.55	0.56	0.62	0.60	0.60	0.59	0.60	0.59	0.45	0.54	0.56	1.00	0.75	0.57	0.48	0.55	0.56	0.58	0.53	0.43	0.44	0.28	0.34	0.37	0.40	0.33	0.52	0.63	0.56
Silicified Wo	0.31	0.45	0.44	0.59	0.51	0.50	0.49	0.50	0.46	0.35	0.42	0.41	0.75	1.00	0.54	0.39	0.49	0.50	0.52	0.42	0.38	0.40	0.32	0.37	0.27	0.32	0.34	0.45	0.44	0.43
quartzite (fre	0.10	0.38	0.38	0.46	0.56	0.57	0.45	0.53	0.38	0.39	0.42	0.30	0.57	0.54	1.00	0.44	0.48	0.43	0.48	0.36	0.30	0.27	0.12	0.17	0.09	0.17	0.21	0.49	0.48	0.49
Medial (freq/	0.04	0.50	0.51	0.49	0.46	0.46	0.36	0.49	0.33	0.66	0.32	0.39	0.48	0.39	0.44	1.00	0.61	0.45	0.66	0.39	0.31	0.38	0.25	0.28	0.33	0.03	0.23	0.55	0.38	0.65
Proximal (fre	0.36	0.77	0.76	0.81	0.58	0.56	0.52	0.68	0.55	0.60	0.61	0.58	0.55	0.49	0.48	0.61	1.00	0.67	0.98	0.74	0.52	0.55	0.42	0.48	0.49	0.45	0.50	0.87	0.78	0.84
Distal (freq/r	0.37	0.65	0.64	0.73	0.54	0.52	0.49	0.61	0.51	0.54	0.55	0.36	0.56	0.50	0.43	0.45	0.67	1.00	0.77	0.57	0.44	0.47	0.36	0.39	0.39	0.43	0.50	0.61	0.53	0.62
Broken (freq	0.36	0.80	0.79	0.84	0.59	0.57	0.51	0.70	0.55	0.63	0.62	0.56	0.58	0.52	0.48	0.66	0.98	0.77	1.00	0.74	0.52	0.57	0.44	0.50	0.48	0.44	0.52	0.86	0.74	0.85
Split (freq/m	0.47	0.72	0.72	0.67	0.53	0.51	0.51	0.64	0.60	0.57	0.60	0.63	0.53	0.42	0.36	0.39	0.74	0.57	0.74	1.00	0.73	0.64	0.54	0.60	0.56	0.56	0.62	0.75	0.76	0.73
Primary Dec	0.43	0.47	0.47	0.41	0.46	0.48	0.49	0.51	0.53	0.49	0.45	0.47	0.43	0.38	0.30	0.31	0.52	0.44	0.52	0.73	1.00	0.76	0.55	0.62	0.53	0.42	0.48	0.59	0.54	0.53
Secondary D	0.40	0.50	0.51	0.48	0.38	0.38	0.38	0.46	0.48	0.45	0.47	0.45	0.44	0.40	0.27	0.38	0.55	0.47	0.57	0.64	0.76	1.00	0.68	0.76	0.66	0.43	0.42	0.59	0.54	0.49
Tertiary Dec	0.50	0.39	0.40	0.33	0.23	0.22	0.29	0.31	0.38	0.28	0.34	0.35	0.28	0.32	0.12	0.25	0.42	0.36	0.44	0.54	0.55	0.68	1.00	0.96	0.72	0.45	0.41	0.52	0.46	0.39
All Decort (fr	0.47	0.43	0.44	0.36	0.25	0.23	0.32	0.34	0.39	0.32	0.36	0.39	0.34	0.37	0.17	0.28	0.48	0.39	0.50	0.60	0.62	0.76	0.96	1.00	0.72	0.46	0.42	0.57	0.51	0.44
Bipolar (freq	0.44	0.46	0.46	0.43	0.29	0.29	0.37	0.38	0.43	0.33	0.36	0.32	0.37	0.27	0.09	0.33	0.49	0.39	0.48	0.56	0.53	0.66	0.72	0.72	1.00	0.48	0.41	0.49	0.55	0.42
Shaping (fre	0.54	0.45	0.45	0.49	0.41	0.40	0.37	0.43	0.58	0.29	0.60	0.52	0.40	0.32	0.17	0.03	0.45	0.43	0.44	0.56	0.42	0.43	0.45	0.46	0.48	1.00	0.49	0.53	0.66	0.33
Bi-Reduct (fr	0.37	0.51	0.50	0.56	0.41	0.40	0.33	0.44	0.43	0.43	0.44	0.41	0.33	0.34	0.21	0.23	0.50	0.50	0.52	0.62	0.48	0.42	0.41	0.42	0.41	0.49	1.00	0.54	0.59	0.48
Hard Hamm	0.31	0.74	0.75	0.70	0.60	0.59	0.53	0.69	0.51	0.68	0.66	0.59	0.52	0.45	0.49	0.55	0.87	0.61	0.86	0.75	0.59	0.59	0.52	0.57	0.49	0.53	0.54	1.00	0.77	0.87
Soft Hamme	0.44	0.72	0.73	0.68	0.62	0.60	0.55	0.70	0.70	0.52	0.68	0.67	0.63	0.44	0.48	0.38	0.78	0.53	0.74	0.76	0.54	0.54	0.46	0.51	0.55	0.66	0.59	0.77	1.00	0.71
Heated SRC	0.27	0.80	0.80	0.77	0.59	0.57	0.53	0.69	0.56	0.75	0.63	0.58	0.56	0.43	0.49	0.65	0.84	0.62	0.85	0.73	0.53	0.49	0.39	0.44	0.42	0.33	0.48	0.87	0.71	1.00

represents non-correlation

represents positive correlation

Table 7.12. Spearman rank order correlation coefficient based on weight.

Mass	FCR n	Deb M	Flakes	Shatter	Fauna	Burne	Cores	Total I	Ochre	Siltsto	Gronlil	Red W	Quartz	Silicifi	Quartz	Media	Proxim	Distal(	Broker	Split(n	Primai	Secon	Tertiar	All De	Bipola	Shapir	Bi-red	Hard H	Soft H	Heated
FCR(freq/ma	1.00	0.27	0.25	0.31	0.29	0.33	0.19	0.54	0.37	0.15	0.48	0.31	0.30	0.29	0.15	0.06	0.17	0.25	0.19	0.37	0.37	0.35	0.44	0.40	0.32	0.31	0.31	0.22	0.34	0.20
Debitage(fre	0.27	1.00	0.95	0.74	0.52	0.65	0.47	0.78	0.60	0.55	0.57	0.49	0.64	0.57	0.51	0.43	0.79	0.61	0.84	0.65	0.61	0.60	0.44	0.56	0.53	0.46	0.50	0.89	0.67	0.91
Flakes(freq/	0.25	0.95	1.00	0.55	0.49	0.62	0.48	0.75	0.55	0.51	0.54	0.45	0.61	0.55	0.51	0.42	0.75	0.59	0.79	0.63	0.61	0.61	0.47	0.59	0.60	0.46	0.45	0.90	0.69	0.90
Shatter(freq/	0.31	0.74	0.55	1.00	0.52	0.57	0.44	0.62	0.58	0.48	0.51	0.48	0.46	0.38	0.35	0.42	0.69	0.46	0.71	0.48	0.41	0.37	0.21	0.28	0.26	0.37	0.45	0.54	0.52	0.63
Faunal(freq/	0.29	0.52	0.49	0.52	1.00	0.82	0.37	0.77	0.54	0.37	0.53	0.46	0.40	0.49	0.45	0.36	0.46	0.32	0.43	0.46	0.39	0.27	0.28	0.30	0.30	0.37	0.44	0.46	0.53	0.50
Burned Bon	0.33	0.65	0.62	0.57	0.82	1.00	0.47	0.72	0.57	0.44	0.59	0.55	0.53	0.50	0.49	0.40	0.58	0.39	0.56	0.57	0.50	0.35	0.21	0.27	0.29	0.33	0.42	0.59	0.61	0.62
Cores(freq/m	0.19	0.47	0.48	0.44	0.37	0.47	1.00	0.38	0.31	0.35	0.34	0.44	0.41	0.39	0.40	0.30	0.55	0.35	0.55	0.40	0.40	0.29	0.26	0.27	0.30	0.21	0.32	0.49	0.40	0.51
Total Items	0.54	0.78	0.75	0.62	0.77	0.72	0.38	1.00	0.67	0.48	0.62	0.47	0.54	0.55	0.53	0.34	0.60	0.46	0.59	0.64	0.58	0.51	0.40	0.50	0.46	0.50	0.49	0.68	0.65	0.71
Ochre (freq/	0.37	0.60	0.55	0.58	0.54	0.57	0.31	0.67	1.00	0.56	0.55	0.54	0.44	0.44	0.30	0.17	0.43	0.38	0.39	0.57	0.48	0.43	0.34	0.37	0.38	0.49	0.33	0.51	0.67	0.49
Siltstone (fre	0.15	0.55	0.51	0.48	0.37	0.44	0.35	0.48	0.56	1.00	0.47	0.56	0.42	0.34	0.37	0.56	0.56	0.37	0.57	0.53	0.48	0.40	0.25	0.29	0.29	0.28	0.34	0.49	0.51	0.58
Gronlid Silts	0.48	0.57	0.54	0.51	0.53	0.59	0.34	0.62	0.55	0.47	1.00	0.70	0.47	0.39	0.34	0.27	0.49	0.41	0.49	0.53	0.47	0.44	0.34	0.41	0.35	0.49	0.47	0.52	0.70	0.56
Red Willow	0.31	0.49	0.45	0.48	0.46	0.55	0.44	0.47	0.54	0.56	0.70	1.00	0.50	0.45	0.35	0.40	0.56	0.30	0.52	0.49	0.48	0.41	0.30	0.35	0.27	0.40	0.36	0.48	0.59	0.52
Quartz	0.30	0.64	0.61	0.46	0.40	0.53	0.41	0.54	0.44	0.42	0.47	0.50	1.00	0.86	0.46	0.36	0.59	0.36	0.58	0.46	0.45	0.42	0.32	0.36	0.34	0.29	0.33	0.61	0.46	0.55
Silicified Wo	0.29	0.57	0.55	0.38	0.49	0.50	0.39	0.55	0.44	0.34	0.39	0.45	0.86	1.00	0.51	0.28	0.54	0.34	0.50	0.37	0.38	0.35	0.31	0.35	0.28	0.30	0.36	0.55	0.41	0.49
quartzite (fre	0.15	0.51	0.51	0.35	0.45	0.49	0.40	0.53	0.30	0.37	0.34	0.35	0.46	0.51	1.00	0.38	0.52	0.23	0.48	0.31	0.32	0.18	0.07	0.14	0.10	0.10	0.19	0.45	0.44	0.48
Medial (freq/	0.06	0.43	0.42	0.42	0.36	0.40	0.30	0.34	0.17	0.56	0.27	0.40	0.36	0.28	0.38	1.00	0.49	0.27	0.55	0.35	0.29	0.30	0.24	0.25	0.31	0.13	0.24	0.37	0.36	0.52
Proximal (fre	0.17	0.79	0.75	0.69	0.46	0.58	0.55	0.60	0.43	0.56	0.49	0.56	0.59	0.54	0.52	0.49	1.00	0.41	0.95	0.52	0.52	0.41	0.33	0.37	0.38	0.36	0.42	0.77	0.60	0.80
Distal (freq/r	0.25	0.61	0.59	0.46	0.32	0.39	0.35	0.46	0.38	0.37	0.41	0.30	0.36	0.34	0.23	0.27	0.41	1.00	0.60	0.41	0.33	0.43	0.28	0.36	0.33	0.36	0.32	0.52	0.37	0.57
Broken (freq	0.19	0.84	0.79	0.71	0.43	0.56	0.55	0.59	0.39	0.57	0.49	0.52	0.58	0.50	0.48	0.55	0.95	0.60	1.00	0.53	0.52	0.49	0.36	0.43	0.40	0.35	0.42	0.78	0.55	0.83
Split (freq/m	0.37	0.65	0.63	0.48	0.46	0.57	0.40	0.64	0.57	0.53	0.53	0.49	0.46	0.37	0.31	0.35	0.52	0.41	0.53	1.00	0.90	0.67	0.53	0.59	0.53	0.44	0.37	0.62	0.57	0.62
Primary Dec	0.37	0.61	0.61	0.41	0.39	0.50	0.40	0.58	0.48	0.48	0.47	0.48	0.45	0.38	0.32	0.29	0.52	0.33	0.52	0.90	1.00	0.69	0.52	0.62	0.52	0.39	0.34	0.61	0.53	0.58
Secondary D	0.35	0.60	0.61	0.37	0.27	0.35	0.29	0.51	0.43	0.40	0.44	0.41	0.42	0.35	0.18	0.30	0.41	0.43	0.49	0.67	0.69	1.00	0.64	0.82	0.65	0.43	0.31	0.59	0.46	0.58
Tertiary Dec	0.44	0.44	0.47	0.21	0.28	0.21	0.26	0.40	0.34	0.25	0.34	0.30	0.32	0.31	0.07	0.24	0.33	0.28	0.36	0.53	0.52	0.64	1.00	0.92	0.71	0.42	0.33	0.51	0.44	0.42
All Decort (fr	0.40	0.56	0.59	0.28	0.30	0.27	0.27	0.50	0.37	0.29	0.41	0.35	0.36	0.35	0.14	0.25	0.37	0.36	0.43	0.59	0.62	0.82	0.92	1.00	0.73	0.44	0.34	0.61	0.47	0.55
Bipolar (freq	0.32	0.53	0.60	0.26	0.30	0.29	0.30	0.46	0.38	0.29	0.35	0.27	0.34	0.28	0.10	0.31	0.38	0.33	0.40	0.53	0.52	0.65	0.71	0.73	1.00	0.37	0.25	0.64	0.51	0.61
Shaping (fre	0.31	0.46	0.46	0.37	0.37	0.33	0.21	0.50	0.49	0.28	0.49	0.40	0.29	0.30	0.10	0.13	0.36	0.36	0.35	0.44	0.39	0.43	0.42	0.44	0.37	1.00	0.35	0.51	0.52	0.41
Bi-Reduct (fr	0.31	0.50	0.45	0.45	0.44	0.42	0.32	0.49	0.33	0.34	0.47	0.36	0.33	0.36	0.19	0.24	0.42	0.32	0.42	0.37	0.34	0.31	0.33	0.34	0.25	0.35	1.00	0.46	0.48	0.44
Hard Hamm	0.22	0.89	0.90	0.54	0.46	0.59	0.49	0.68	0.51	0.49	0.52	0.48	0.61	0.55	0.45	0.37	0.77	0.52	0.78	0.62	0.61	0.59	0.51	0.61	0.64	0.51	0.46	1.00	0.63	0.90
Soft Hamme	0.34	0.67	0.69	0.52	0.53	0.61	0.40	0.65	0.67	0.51	0.70	0.59	0.46	0.41	0.44	0.36	0.60	0.37	0.55	0.57	0.53	0.46	0.44	0.47	0.51	0.52	0.48	0.63	1.00	0.61
Heated SRC	0.20	0.91	0.90	0.63	0.50	0.62	0.51	0.71	0.49	0.58	0.56	0.52	0.55	0.49	0.48	0.52	0.80	0.57	0.83	0.62	0.58	0.58	0.42	0.55	0.61	0.41	0.44	0.90	0.61	1.00

represents non-correlation

represents positive correlation

A wide variety of correlations were detected with the Speaman's coefficient. A positive correlation occurred between all faunal remains and burned bone. A strong correlation existed between Gronlid siltstone and Red Willow Creek silicified sandstone distributions; this observation was interesting as both materials were knapped in the same locale, likely at the same time by one individual. Thus, the Spearman's statistic can isolate the distributional patterns of individual activities.

Correlations were detected between various breakage forms, percussor types, decortication flake types and bipolar technology. The correlations between the various breakage forms indicate that hard hammer percussion regularly fragmented flakes. Also, soft hammer percussion broke flakes, but to a lesser degree than hard hammer percussion. Decortication patterns indicated that primary and secondary decortication flakes strongly co-occurred, and that tertiary decortication and total decortication flakes had a near perfect correlation. This pattern described the overabundance of tertiary versus primary and secondary decortication flakes. A strong relationship occurred between bipolar reduction and all decortication flakes, especially tertiary decortication. This correlation supports the observation of bipolar technology as a core reduction strategy. Hard and soft hammer flake distributions were strongly related, evidence that percussion reduction occurred in the same locations.

An important pattern was present between the distributions of cores and other flake types. Of note was a lack of correspondence between decortication flakes and cores by weight. Contour density plots of this relationship are illustrated on Figure 7.6. The observed pattern went against the expectation that cores were discarded in the same locales as decortication flakes. From the distribution charts, *it is apparent that cores were discarded close to reduction areas, but not within them*. Cores were discarded on the periphery of lithic reduction areas. Importantly this is not a formation of the Binford (1978) drop and toss zones. Instead it is a subtler, diffuse pattern of refuse disposal. This core discard pattern is an important observation that has been noted elsewhere in the archaeological record. Kvamme (1996:51) noted that:

> The distribution of cores in the project area is certainly relevant to any investigation dealing with debitage distributions. One might assume, for

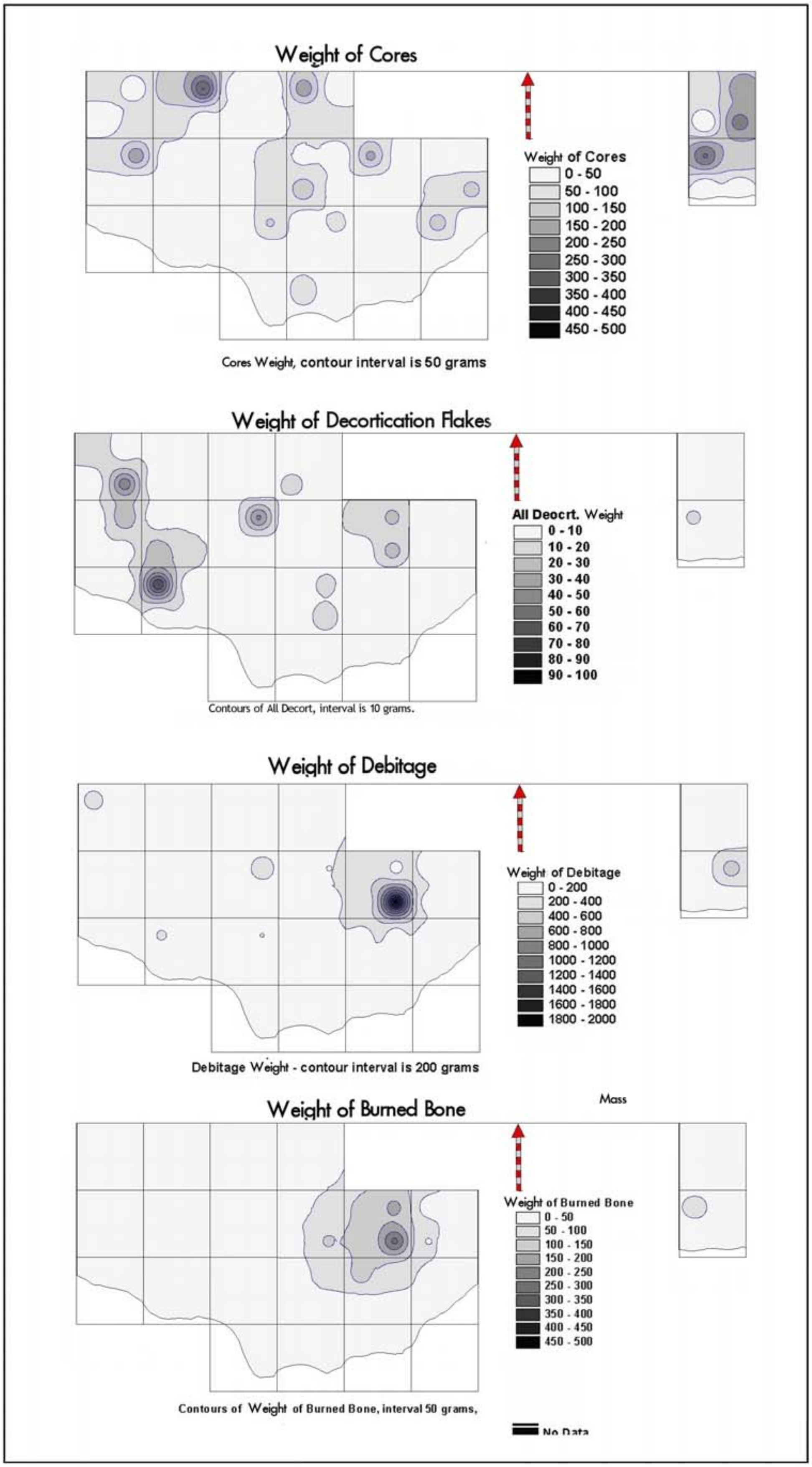


Figure 7.6. Contour density plots of various artifact types, lower occupation.

> example, that cores might exist at those places where flaking activity occurs, at least in its initial stages. It therefore came as a suprise when I observed, through GIS mapping, a strong pattern of "rings" of cores surrounding the margins of many of the flake clusters.

For Kvamme's research, the study area was a surface collection of a 6-Ha area in a desert region of Colorado, with components from the Early Archaic to recent times (Kvamme 1996:41). Although our scales were different, the pattern remained the same, rings of cores surrounded the knapping areas. I argue that the rings of cores might be a modal form of discard that cross-cuts scale, as illustrated on Figure 7.7. With this stated, it needs to be tested with additional spatial research. To conclude, cores were differentially discarded away from the knapping areas. The observation is supported statistically.

To summarize, the Spearman rank order correlation coefficient was a valid method to identify the nature of artifact class distributions. It provided a straight forward method to analyze multiple classes of data with respect to each other, and allowed for quantifiable support for patterns observed in the contour density plots.

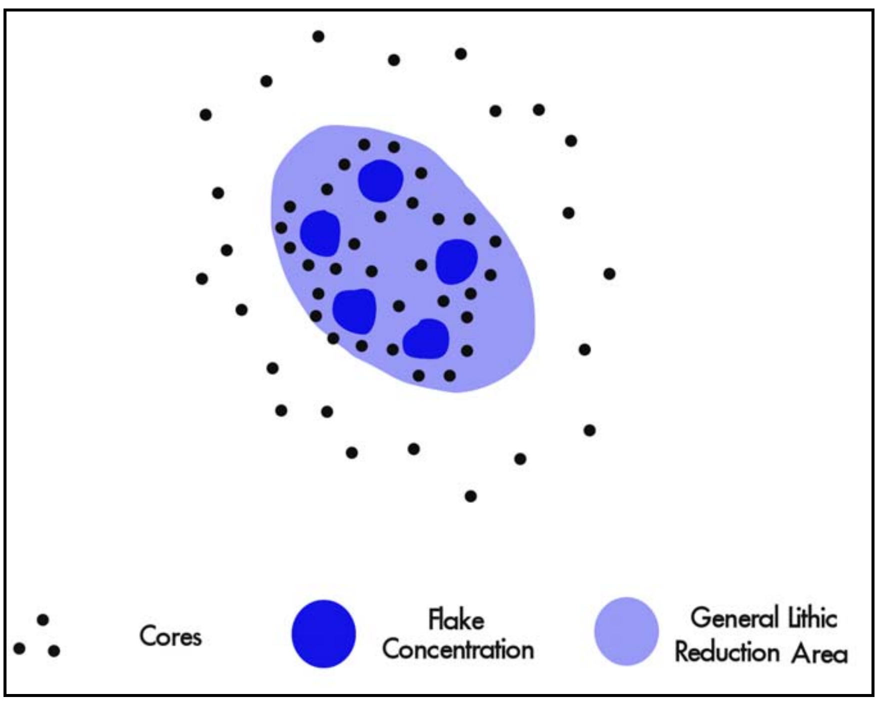


Figure 7.7 Outward trending modal form of core discard.

7.5.3 Comparison of Pearson's and Spearman's Correlation Coefficients.

The Pearson's R statistic was problematic: very few strong correlations were identified, and some values were unrelated in test cases. For instance, debitage and shatter were described as being unrelated by the Pearson's R though debitage and shatter distributions were certainly related. Thus, the Pearson's R method showed indeterminate correlations between artifact classes, when in fact they were substantially related. Only one strong negative correlation was identified with the Pearson's R method. A great abundance of non-corresponding relationships was the outcome of the method. When compared to Spearman's rank order method, it was apparent that there were substantial problems with the Pearson's R method. These observations confirm Kvamme's (1996:47) findings: "Pearson's R is a well known measure of association, but it often falls apart in spatial contexts". Kvamme identified that the major problem of Pearson's R coefficient was that it was an aspatial statistic affected by chaotic distributions, outliers and large null numbers, low cell values, and raster grid size (Kvamme 1996). The Pearson's R method also required a linear relationship between compared data sets, which is rare in archaeological data (Wheatley and Gillins 2002:130-134). Problems also include that Pearson's R is a parametric test. In contrast, Spearman's R test was a non-parametric statistic. From the Moran I and Geary C tests presented earlier, the majority of Below Forks spatial distributions were shown to be non-parametric. So a contribution of this thesis is the clarification that Pearson's R should not be used to spatially compare archaeological data sets. Instead, the Spearman's rank order correlation coefficient is the better method.

7.6 Chapter Seven Summary.

A spatial analysis was conducted on the various components in the eastern area of the Below Forks site. Contour density plots were created to identify distributions of various artifact classes. Throughout, lithic technology was the focus of the spatial analysis. Features and activity areas were defined. Moran I and Geary C autocorrelation tests were used to describe the clustering and dispersal of artifact types. Various densities of artifact classes were compared with Pearson's R and Spearman's rank order correlation coefficients. The spatial analysis was primarily conducted with *ArcView 3.2*, while *Microsoft Excel 2000* aided the Spearman's rank order statistic.

The spatial analysis of lithic technology was useful to identify activity and reduction locales, and to clarify relationships between artifact classes. Rings of cores were present around the periphery of lithic reduction areas. Fire cracked rock use occurred in a separate activity area. Flake concentrations were defined. Gronlid siltstone and Red Willow Creek silicified sandstone occurred in a localized activity area distinct from the rest of the lithic reduction assemblage. A non-correspondence occurred between thermally alterated debitage and burned bone. A pit filled with burned bone had a superimposed knapping station. A greater amount of flake breakage was associated with hard hammer percussion than soft hammer. Primary and secondary decortication co-occurred while tertiary decortication flakes were spatially distinct. This pattern indicated differing core reduction areas, and a separation of the decortication process into two stages, an early stage composed of primary and secondary decortication, and a later stage represented by tertiary decortication flakes. The distributional analysis clarified activity areas, lithic technology stages, and cultural disposal patterns.

The spatial statistics described spatial concentration and interrelationships of artifact classes. Archaeological spatial analysis was well suited to GIS; it was expedient and straight-forward. The most significant problem encountered was that the sample sizes of the upper and middle occupations were too small for valid statistical spatial analyses. While problems were noted, questions regarding lithic technology were aptly studied by spatial means. Lithic reduction consisted of activities with spatial residue.

"Laboring on the tilt of that steep grade,

Behind which the declining moon has set."

Sylvia Plath (1981:334), from

The Princess and The Goblins.

8. DISCUSSIONS AND CONCLUSIONS.

8.1 Introduction.

Over the previous chapters an analysis of the lithic remains from the Below Forks site was presented. Of most importance was the detailed analysis of debitage. Material types, detachment techniques, and platform preparations were identified within a flake typology. Cores were analyzed with regard to variations of preparation and reduction strategies. In turn, the tools received attention as to the techniques of their manufacture. Analyses of debitage, cores and tools were set into a spatial context, mainly with GIS. Technological activity areas were identified in the various components of the site with the spatial analysis. This chapter organizes observations from these analytical strategies together to complete the interpretation of lithic technology. Suggestions for future research and a general conclusion close the chapter.

8.2 Lithic Technology of the Below Forks Site.

8.2.1 A Return to the Ten Questions of Lithic Technology

The interpretation of lithic technology now returns to the ten question that have guided the research. From chapter one, these questions were:

1. What were the types of lithic raw material present in the site?
2. What was the ratio of local, regional and exotic materials at the site?
3. What type of preparations were done on the raw material?
4. What was the nature of thermal alteration in the lithic assemblage?
5. At what stage did thermal alteration occur?
6. What were the relative stages of tool manufacture?
7. At what stages were hard hammer, soft hammer and pressure detachment techniques applied?
8. What was the type of core reduction technology?

9. What was the type and distribution of platform preparation in the stages of manufacture?

10. What was the tool assemblage? Were there distinguishable techniques in the manufacture of individual tool types?

These questions are answered in groups due to their inter-related solutions and interpretations. Questions one and two are answered in a discussion of material type. Questions three, four and five all relate to the nature of thermal alteration. The interpretation of reduction stages addresses questions six and seven. Question nine deals with platform preparations and is treated separately. Finally the answer to question ten, the methods of tool manufacture, closes the interpretations. As these questions are addressed an interconnected interpretation of the lithic technology of the Below Forks site will become apparent.

8.2.2 Raw Material Utilization.

The vast majority of lithic raw material present at the site was Swan River chert. Swan River chert was collected to the exclusion of other common locally available materials. Though these materials, namely quartz, quartzite, siltstone, limestone, and Gronlid siltstone, were reduced they were not exploited as intensively, nor were they as important as SRC. Swan River chert composed 95 % of all of the raw material recovered from the site. Clearly, all the components of the eastern area indicate the continuous importance of SRC through time. These raw materials were procured from locally available deposits, most likely from glacial till exposed as river cobbles or in valley-side exposures. Different materials were preferred for different tool types. Swan River chert was preferred for most tool types, including bifaces, projectile points, 'regular' unifaces and the majority of the retouched debitage. In contrast, quartzite was selected for reverse unifaces.

The proportions of local, regional and exotic materials provide an indication of general subsistence/settlement patterns. The study of raw material utilization is a means to identify mobility patterns (Amick 1995; Bamforth 1986), seasonal rounds (Holen 1991; Odell 1999), and macroband ranges (Anderson and Hanson 1988; Francis 1983:236-237; Gould and Saggers 1985:122). A study of this sort is possible through the relationship of material sources, and their relative proportions in archaeological sites. Appreciably, over 99 % of the lithic raw materials at Below Forks were locally available. This is unsurprising as the site was a collection locale. Less than 1% of the material was regionally available Red Willow Creek silicified sandstone. Observation of the reliance on local resources reinforces an interpreted subsistence/settlement pattern associated with the Saskatchewan River system. Trace amounts of exotic materials were present, namely chalcedony, silicified wood and silicified peat. Often, exotic materials indicate a form of trade (Amick 1995; Nehik 1986). Trade is usually defined in an economic sense, as the redistribution of material goods across space between groups of people (Fladmark 1984:154-155, Friedman and Rowlands 1977:224-247). I disagree with this definition. Rather I view trade as the adaptive maintenance and reinforcement of social ties between social groups across the cultural landscape. The material portion of trade, specifically exotic materials, are just a small representation of a larger cultural pattern, as suggested by Gould (Gould 1977,1980:155-159; Gould and Saggers 1985). This form of trade should be viewed as gift-exchange rather than of significant economic importance, though this surely occurred (Hodder 1982:199; Renfrew 1975:5). Each instance of trade should be carefully assessed for its cultural significance. The presence of trace amounts of exotics, namely silicified peat and chalcedony, indicate a connection to south central Saskatchewan for the former occupants of the lowest component of the Below Forks site.

The collection of raw material is often linked with seasonality. Materials are procured when exposed and accessible. Winter is a major concern for quarrying activities for sites in high elevations and in northern latitudes (Francis 1983:226-231; Fladmark 1984). Often access to materials is curtailed in this season. At the Below Forks site frozen ground and snow cover would have made the river cobbles inaccessible. Similarily, snow would have greatly increased the difficulty for collecting stone from valley-side exposures. Although provisional on a faunal analysis, the lower component of the site was occupied in late winter or early spring. Importantly, as the site is located below a south-facing slope, river cobbles were more accessible here at this time than on the other side of the river. In the context of material procurement the timing of occupation at the site locale made sense.

8.2.3 The Relative Stages of Tool Manufacture.

Lithic technology was set into *chaîne opératoire*, a framework for the relative stages of manufacture (Bleed, 2001; Dobres 2000:149-157; Sellet 1993). Generally the *chaîne opératoire* are separated into core reduction strategies and preform reduction strategies, and finish with tool discard (Kuhn 1995:15-16). Core reduction is represented in *les eclat de debitage*, early stage debitage (Villa 1983:154). Broadly identified, a core reduction strategy is the method of transforming cores into flake blanks. Preform reduction is represented in *les eclat de taille*, late stage debitage (Villa 1983:154). The modification of flake blanks into finished tools represent the preform reduction strategies. Tool production from cores to finished tools occurred as a continuum of reduction, and not in well defined stages. Instead, the relative stages of reduction provide an arbitrary analytical system to categorize artifact variation. With that stated, the stages of reduction should be taken as a guide to the reduction process of tool manufacture and not as a true representation of the cognitive stages of former flint-knappers.

Of initial importance was the selection of raw material. Once a raw material was selected, it was tested with an experimental flake removal or two to insure that the physical characteristics were proper for tool manufacture. This action was represented *in situ* by recoveries of tested cobbles. Entire cores of Swan River chert or Red River chert were set aside for thermal alteration if necessary after testing.

Three basic post-testing core reduction strategies occurred: a bipolar, a bifacial, and an amorphous strategy. Bipolar techniques were used to create flake blanks of a consistent size and thickness. Significantly, these flake blanks had a flat ventral surface. Bipolar flake blanks were reduced into specific tool types. From the lower component, a side-scraper was manufactured on a bipolar core, and the reverse unifaces were all manufactured on early bipolar decortication flakes. Figure 8.1 presents the bipolar manufacture strategy.

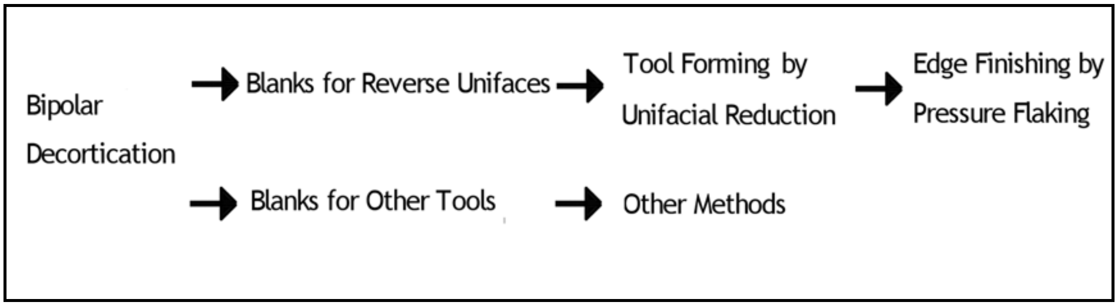


Figure 8.1. Reduction sequence to manufacture reverse unifaces.

The second core reduction strategy was the formation and reduction of bifacial cores to remove flake blanks. Flakes were removed from bifacial cores with noticeably more platform preparation, indicating that additional care was taken to control detachment. From the assemblage, it is seen that bifacial cores were reduced for flake blank production and were not used as tool preforms in themselves. All bifacial cores lacked tool-edge forming, thinning, or usewear. Supporting the observation was an absence of bifacial core characteristics on bifaces. In addition, bifacial core choppers were absent from the assemblage.

Amorphous core reduction represents the third strategy. These cores exhibited some platform preparations, but did not have a well planned strategem of flake removal. Instead, flakes were struck off opportunistically depending on platform exposure and the relative form of the arrises remnant from previous flake removals. The amorphous core-reduction strategy was an indication that flint-knappers were limited by and accommodated for the raw material.

All core reduction strategies had the same general purpose: core reduction to produce flake-blanks for further refinement into tools. Appreciably, the core reduction strategy utilized was partly based on intended flake-blank structure and partly based on the nature of raw material. Figure 8.2 summarizes the core testing, preparation and reduction strategies.

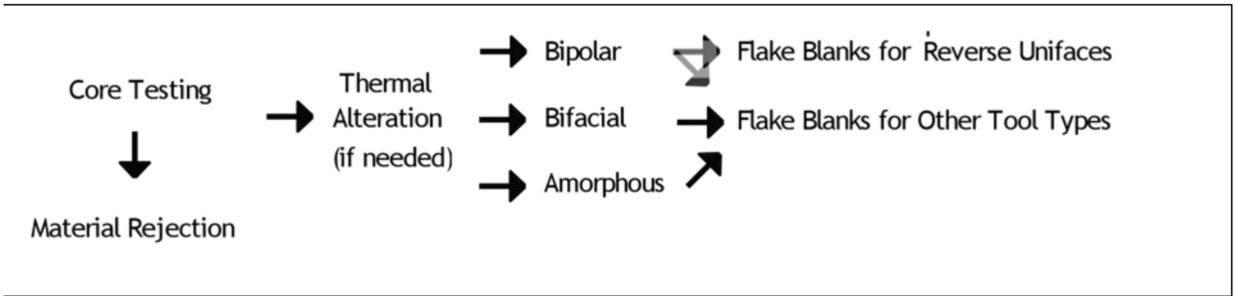


Figure 8.2. Core reduction strategies.

Bipolar technology was used early in the sequence of reduction. This was evident since some secondary and tertiary decortication flakes were removed with bipolar techniques. Bipolar flakes without exterior cortex represented a continuation of bipolar core reduction past decortication. Bipolar flakes were the largest flake types. Notably, tools were not shaped, formed or finished with bipolar reduction techniques. With that stated, the singular exception was the pièce esquillées, a tool formed through use in a bipolar situation, as between a hammer and an organic anvil, and not directly with a bipolar technology, as between a hammer and an anvil-stone. Thus bipolar technology was limited to core reduction and the production of flake blanks. Evidently, the bipolar technique was not used as a method to conserve raw material. Bipolar reduction expressed at Below Forks does not include typical split-pebble technology. This reduction strategy is more commonly associated with the Mummy Cave series (among other archaeological complexes) of the Canadian Prairies (Low 1996:224-243; Quigg 1984; Walker 1992:63-65,89-90). The absence of split-pebble technology can readily be explained to the nature of Swan River chert nodules in glacial till. Often large, amorphous and slightly rounded nodules of SRC are recovered. Split-pebble techniques practiced on nodules of Swan River chert will likely fail. Whereas in typical expressions of split-pebble technology commonly utilized materials are small pebbles, usually of silicified siltstone, and sometime of an indeterminate chert. In sum, bipolar technology was an important component of Below Forks ltihic reducton strategies.

Freehand decortication occurred with hard hammerstones and represented bifacial and amorphous core reduction strategies. Figure 8.3 outlines the nature of core reduction for the production of flake blanks. From the debitage analysis, decortication flakes metrically appeared as a continual gradation of size and were not separable into stages. Unexpectedly, the spatial analysis of decortication flakes indicated that there were two spatially distinct stages of decortication, an early and a late stage. The early decortication stage consisted of primary and secondary decortication flakes, with exterior cortex occurring between 50 and 100%. The late decortication stage consisted of tertiary decortication flakes, with 1 to 50 % exterior flake cortex.

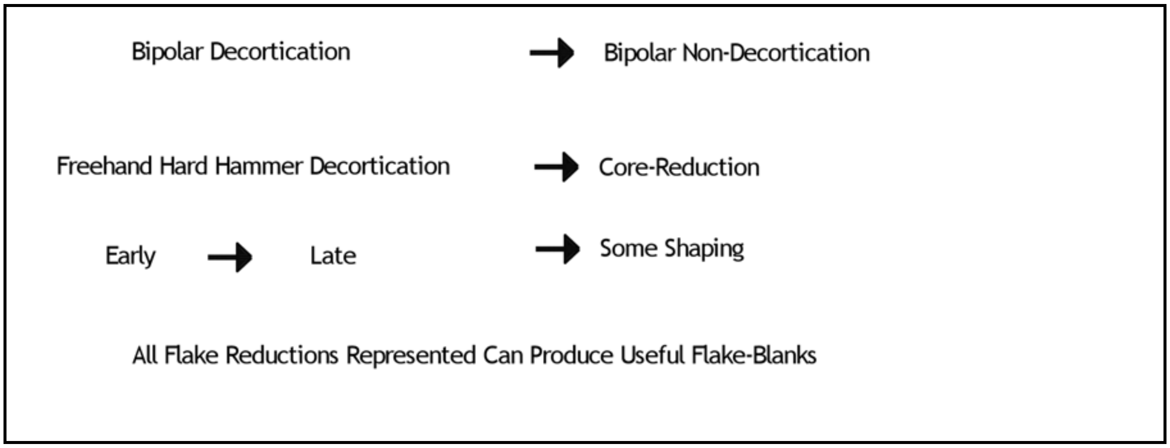


Figure 8.3. Core reduction for flake-blank production.

Shaping and core reduction flakes were removed both from cores and from flake blanks. Core reduction flakes were medium sized pieces removed from cores and had a complex exterior surface. These flakes were removed for use as flake blanks or to 'prime' cores for blank removal. Shaping flakes were generally associated more with preform reduction than with core reduction. These flake types were removed with a hard hammerstone in about 75% of the cases, while the remaining 25% were removed with a soft hammer. It was in the course of preform reduction that the hard hammerstone was exchanged for a soft hammer billet. Shaping flake removals began the transformation of flake blanks into tool preforms, then unifacial and bifacial reduction refined the tool shaping. Unifacial reduction flake removals formed the working edges of unifaces. In the debitage analysis unifacial reduction flakes were rarely identified. Their rarity in the debitage analysis is problematic, but as observed on unifacial tools, unifacial reduction flakes often had a length less than ten millimetres. These flakes were missed in the detailed debitage analysis, being smaller than the size cut-off. Confounding the problem was that the exterior flake curvature associated with unifacial reduction is often subtle, such that unifacial reduction flakes may have been classified as bifacial reduction flakes

(Crabtree 1982). The problem rests in the size-range and possible misidentification of unifacial reduction flakes. A defining characteristic of bifacial reduction flakes is a complex platform surface formed though extensive flaking (Crabtree 1982). Importantly, bifacial reduction was mostly conducted with a soft hammerstone, in about 75% of the cases, but hard hammer percussion did remove some bifacial reduction flakes. Although the sample size was too small for substantive confirmation, hard hammer percussion was also used to detach unifacial reduction flakes.

The preform reduction strategy finished with pressure retouching along the margins of the tools. Pressure flaking mainly defined the tool edge; it also thinned the implement. Figure 8.4 diagrams the total preform reduction strategy represented at the Below Forks site. The detailed debitage analysis did not identify many pressure flakes, as most pressure flakes were smaller than ten millimetres. The debitage smaller than ten millimetres did contain abundant numbers of pressure retouch flakes. Indeed, I think that the majority of lithic remains from six to three millimetres in size were pressure flakes, and thousands were recovered from excavations. Pressure flake removals were readily identified on tools. On the whole, tool manufacture was a continuum from core reduction through preform reduction and tool finishing, and generally spatially co-occurred.

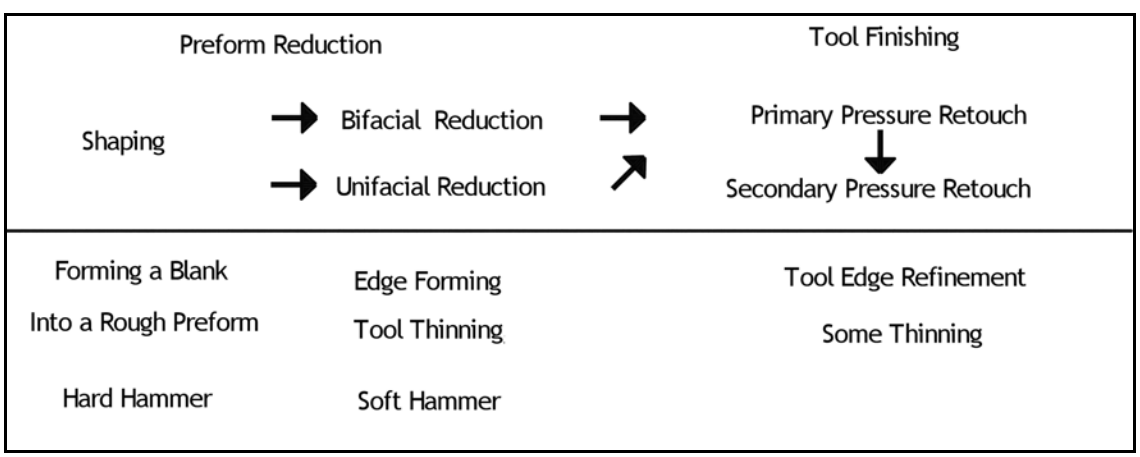


Figure 8.4. A summary of tool manufacture from flake-blanks.

8.2.4 The Tool Assemblage

The artifact assemblage presented diverse forms of lithic implements that were used in a variety of activities. Few tools were recovered from the upper component. It had one hammerstone and an individual piece of retouched debitage. On the whole, a lithic reduction workshop and some habitation debris were represented in the upper occupation. The middle occupation had a sparse recovery of tools; a biface and a retouched flake were present. This component represented cultural materials peripheral to a habitation site. Faunal butchery was indicated with the presence of the biface and retouched flake. A relatively greater diversity and amount of tool forms were present in the lower occupation. An anvil-stone and two hammerstones were recovered in association, and document bipolar technology. Ten bifaces, three projectile points and a pièce esquillées were retrieved from excavations. A chithos-like object and a multipurpose chopper/abrader were recovered. The discovery of 21 retouched pieces of debitage and a utilized flake indicate former animal butchery activities. The overall tool assemblage indicated lithic tool manufacture, some hunting, butchery, hideworking and the modification of organic remains with a pièce esquillées. Although the primary activity represented in the lower occupation was tool production, the diversity of tool forms indicated that this component was a workshop situated in a habitation site.

All of the recovered tools, other than the hammerstones, anvil, multipurpose and chithos-like objects, were manufactured on flake blanks. Unifacial tools were sometimes shaped, then refined with unifacial reduction and finished with pressure retouch. Bifacial tools were often shaped, followed by thinning with bifacial reduction, and finished with pressure retouch. Reverse unifaces were manufactured on early stage decortication flakes, and were only formed with soft-hammer unifacial reduction flakes along the distal margin. They were sometimes finished with pressure flaking along the working enge. Evidently, external decortication and shaping did not occur for these tools. Retouched debitage often had an edge created through pressure retouch, and occasionally exhibited unifacial or bifacial reduction flake scars. Shaping did not occur on these tools. One utilized flake exhibited marginal usewear from cutting activity. The pièce esquillées exhibited heavy usewear and minimal forming with pressure retouch.

General tool discard patterns were indicated through the interpretation of tool breakage and usewear. Some tools were discarded due to step fracture breakage. The fracture sometimes occurred during manufacture, but often happened during or after an item's utilization. Bifaces and endscrapers were commonly broken in this manner. Retouched and utilized debitage were used for a short duration and then discarded, evident with their slight usewear. Reverse unifaces and the pièce esquillées were heavily used, and were discarded when their working edges became dull. Some of the implements were tool preforms that were discarded before finishing. Importantly, each tool had its own use-life and artifact history. Only the general tool discard patterning is presented herein.

8.2.5 Thermal Alteration.

Thermal alteration was an important aspect of the technology of lithic tool manufacture. Thermal alteration improved the knapping quality of the stone by allowing flakes to detach through mineral grains, rather than around them. Following Leudtke (1992), different physical models of thermal alteration were presented, namely the silica fusion and crack models. The analysis of the fractal dimension of thermally altered and unaltered materials confirmed the crack model. Microfractures in the material are redistributed and make flake detachment more homogenous, and thus more controllable by flint-knappers. Thermal alteration occurred on entire cores. It was observed on 78 % of the cores and 82 % of the debitage. Swan River chert and Red River chert manifested thermal alteration.

Heat treating features were not recovered at Below Forks. Indeed, discussions of these features are exceedingly rare in the archaeological literature (Bakken 1995). Technical processes often have a sacred or ritualized component to them. Gould and Saggers (1985:122) have noted the sacred role of lithic material types for hunter-gatherers. Lindgren (2003:178), on observing Mesolithic material variation of tool types, hypothesized that the production of tools imparts magic to these tools. She stressed that the *technological process of manufacture itself* imparts this magic. In an ethnographic situation, Gell (1992:44) stated that: "the enchantment of technology is the power that technical processes have of casting a spell over us so that we see the real world in an enchanted form". Although it is speculative, one can hypothesize that there was cultural meaning implied in the thermal alteration process. Not only the physical, but the cultural properties of an object can change during the heat treatment process. The metamorphosis of a substance from one form to another, like a shift in colour, may have indicated a metaphysical change. An extension of the hypothesis is that the locale and timing of the thermal alteration process was of ceremonial significance. From the paucity of thermal alteration features, the only conclusion remains: these features represent activities of low archaeological visibility located in areas away from main camp and kill sites.

8.2.6 Platform Preparations

Platform preparation was consistently observed in all of the components of the Below Forks site. Although differences in the relative proportions of preparation occurred between the components, a general continuity of preparation methods were observed. The grinding of platforms consistently appeared on debitage regardless of reduction stage. An associated increase in platform flaking was identified on later stages of reduction. It was determined that platform shape was analytically unimportant for the study of lithic technology.

Platform preparations were noticeably different with regard to core reduction strategies. Bipolar cores had the definitive platform crushing and also platform edge and surface grinding. A significant amount of platform preparation was present on bifacial cores. Platform grinding and surface flaking were well represented on these cores. Amorphous cores exhibited platform edge and surface grinding to a lesser degree than the other core types. The preparations of platforms were important methods to control individual flake detachment. Platform grinding was common, and served as a foundation principle for Early Side-notched/Mummy Cave series lithic technology.

8.3 Future Research Directions.

This thesis has clarified my thoughts on archaeology and presented a vision of Early Side-notched/Mummy Cave series prehistory that warrants future research. Detailed debitage analyses from a variety sites of different ages should be conducted to build a culture history of lithic technology. Such a study should note aspects of platform preparation, flake typology, and reduction strategems. Thermal shock was identified as an important observable material trait. The hypothesis that thermal alteration technology may have deteriorated over time should be tested by investigating the relative nature and proportion of thermal shock over time. An analysis of cores should be included as a part of everyday site analyses. Core analysis is straightforward and relatively expedient, and often indicates differing techniques of core reduction. Three dimensional models of other sites should be constructed to better define features of cultural behaviour, such as households or kill site strategies. Appreciably, these models can be created from previous excavations, if the data collection was of high resolution. Interpreting the regional distribution of Early Side-notched/Mummy Cave series sites along the Saskatchewan River systems is of value for predictive modelling. Specifically, the North Saskatchewan River system deserves attention for the reconnaissance of sites of the Mummy Cave series. Diagnostic tool types other than projectile points deserve investigation as they provide an extension of cultural chronologies, and may indicate the nature of past social groups, and their distribution across space. A summary of raw material proportions present in many sites of similar age with wide spatial distribution should be conducted. This method may identify regional bands and changes in their seasonal rounds over time. The faunal assemblage of the Below Forks site deserves attention, as do the plant macrofossils. Such an investigation would test the proposed generalist adaptive strategy.

8.4 Conclusions.

The lithic technology of Below Forks was studied in great detail. The method of tool manufacture was the central theme of study. Table 8.1 documents the amount of archaeological material studied herein. A variety of analytical techniques were used, including the separate analyses of cores, debitage, and tools. The debitage, tool and cores analyses were placed into a spatial context with GIS. Clustering of artifacts around foci were observed in the spatial analysis. Where possible these clusters were interpreted as activity areas. Spatial statistics, three dimensional modelling, and expediency in GIS analysis were of value and suited archaeological inquiry well. This strategy assessed the problem of stragraphic mixing. It also provided a means to take mixing in to account for later analyses.

Three components were represented in the eastern area of the Below Forks site. A lithic reduction workshop and some habitation debris were contained in the upper occupation. Evidently, the middle component appeared peripheral to a habitation site. The lower occupation evidenced significant knapping activities within the confines of a habitation site. An important activity was the collection of SRC from nearby river cobbles. Bison was the focus of a generalist subsistence strategy. The projectile points recovered from the lowest component are diagnostic to the Early Side-notched/Mummy Cave series, and are reminisent of Gowen forms. Such an interpretation is supported by the dates of 5500 to 6000 rcybp and the positioning of the site on a middle level alluvial slope of the Saskatchewan River. The upper and middle components are of unknown temporal position.

Table 8.1. Frequency of material from the eastern area of the Below Forks site.

Material Type	Debitage	Cores	FCR	Faunal Remains	Ochre	Tools	Total
Microdebitage/Features	4511	0	0	4763	0	0	9274
<1cm	18285	0	119	20419	40	0	38863
>1cm	5592	118	220	2362	8	57	8357
Total Artifacts Without Micro.	23843	118	339	22748	57	57	47162
Total Artifacts Including Micro.	28388	118	339	27544	57	57	56503

Total Artifacts Without Micro-analysis.	47162
Total Artifacts Including Micro-analysis.	56503

Interpretations from various analytical techniques were placed within a *chaîne opératoire* framework and fully documented lithic technology. Certain types of material behaved in slightly different ways, and individual knappers would have taken this into account and appropriately modified their technique. The thermal alteration of SRC was an important component of lithic technology. Bipolar technology had a prominent role in the production of flake blanks. Platform grinding was a commonly observed form of platform preparation. Platform flaking increased in importance with later stages of reduction. Ideally these preparations would allow a flint-knapper to improve their control of intended flake detachments. Unfortunately, regardless of platform preparation, step fracture of the flake during detachment was a frequent outcome of these efforts. In sum, lithic tools were manufactured within a myriad of technological sophistication. The properties of lithic fracture were controlled with great precision, preparation, and foresight in the manufacture of implements at the Below Forks site.

REFERENCES CITED

Aaberg, S.A., L.B. Davis, G.G. Fredlund, L.S. Cummings, and K. Puseman.
1996 Barton Gulch site geochronology and paleoecology. *Current Research in the Pleistocene* 13:85-87.

Adams, G. F.
1977 *The Estuary Bison Pound Site in Southwestern Saskatchewan.* Archaeological Survey of Canada, Mercury Series 68. Canadian Museum of Civilization, Hull, Quebec.

Ahler, S.A.
1979 Functional Analysis of Nonobsidian Chipped Stone Artifacts: Terms, Variables and Quantification. In Lithic Use-wear Analysis, B. Hayden, editor. Academic Press, New York. Pp. 303-328.

1983 Heat Treatment of Knife River Flint, in *Lithic Technology*, 12(1):1-8.

1986 *The Knife River Flint Quarries: Excavations at Site 32DU508*. State Historical Society of North Dakota, North Dakota Heritage Centre, Bismarck.

1989 Mass analysis of flaking debris. In *Alternative Approaches to Lithic Analysis*, edited by Henry and Odell, pp 85-118. Archaeological Papers of the Anthropological Association Number 1. Washington, D.C.

Alex, L.M.
1991 *The Archaeology of Beaver Creek Shelter (39CU779), Wind Cave National Park, South Dakota: A Preliminary Statement*. South Dakota School of Mines and Technology, Rapid City, South Dakota.

Alighieiri, D.
1980 *The Divine Comedy*. Regnery Gateway Press, Chicago.

Alvi, Z.
1995 *Statistical Geography: Methods and Applications*. Rawat Publications, New Delhi, India.

Amick, D.S.
1995 Regional patterns of Folsom mobility and land use in the American Southwest. *World Archaeology* 27(3):411-426.

Andrefsky, W. Jr.,
1998 *Lithics: Macroscopic approaches to analysis*. Cambridge Manuals in Archaeology. Cambridge University Press, London.

Anderson, D.G. and G.T. Hanson.
1988 Early Archaic Settlement in the Southeastern United States: A Case Study from the Savannah River Valley. *American Antiquity*. 53(2):262-286.

Archibold, O. W., and M. R. Wilson.
1980 The Natural Vegetation of Saskatchewan Prior to Agricultural Settlement. *Canadian Journal of Botany* 58:2031-2042.

Arsenault, A.A.
1998 *Saskatchewan Elk (Cervus elaphus) Management Strategy. Fish and Wildlife Technical Report 98-1*. Saskatchewan Environment and Resource Management, Fish and Wildlife Branch. Saskatoon.

2000 *Status and Management of Moose (Alces alces) in Saskatchewan. Fish and Wildlife Technical Report 00-1*. Saskatchewan Environment and Resource Management, Fish and Wildlife Branch. Saskatoon.

2003 *Status and Management of Wildlife in Saskatchewan, 1999-2000. Saskatchewan Environment, Fish and Wildlife Technical Report 2003-1.76*. Saskatchewan Environment and Resource Management, Fish and Wildlife Branch. Regina.

Atton, F.M. and J.J. Merkowsky.
1983 *Atlas of Saskatchewan Fish. Fisheries Technical Report 83-2.* Fisheries Branch, Department of Parks and Renewable Resources, Regina.

Bakken, K.
1995 Lithic Raw Material Resources in Minnesota. Paper presented at the annual meeting of the Society for American Archaeology, Minneapolis, May 3-7, 1995. http://www.tc.umn.edu/~bakk0029/MinnLith/undex.html. Accessed November 11, 2003.

Bacon, C. R.
1983 Eruptive History of Mount Mazama and Crater Lake Caldera, Cascade Range, U.S.A.: *Journal of Volcanology and Geothermal* Research, 18:57-115.

Baille, A.D.
1952 Ordovician Geology of Lake Winnipeg and Adjacent Areas, Manitoba. Province of Manitoba, Department of Mines and Natural Resources, Mines Branch Publication 51-6. Winnipeg.

Bamforth, D.B.
1986 Technological efficiency and tool curation, *American Antiquity* 51(1):38-50.

2002 High Tech Foragers? Folsom and Later Paleoindian Technology of the Great Plains. *Journal of World Prehistory*, 16:55-98.

Banga, A.B. and R.J. Blain.
1981 *1977 Operation of the Saskatchewan River System Hyd-6-41*, prepared by Operating Planning Division, Hydrology Branch, Saskatchewan Environment. Regina.

Bang-Anderson, S.
2003 Encircling the living space of Early Postglacial reindeer hunters in the interior of southern Norway. In *Mesolithic on the Move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000*. L. Larsson, H.K. Kindgren, K. Knutsson, D. Leoffler and A. Akerlund (Eds.) Oxbow Books. Oxford. Pp. 193-204.

Bates, R.L., and J.A. Jackson (eds).
1984 *The Dictionary of Geological Terms*, Third Edition, Anchor Press/Doubleday, Garden City, New York.

Baumler, M.F.
1985 On the Interpretation of Chipping Debris Concentrations in the Archaeological Record. *Lithic Technology*, vol. 14, No. 3. 120-125.

1988 Core Reduction, Flake Production, and the Middle Paleolithic Industry of Zobište (Yugoslavia) in *Upper Pleistocene Prehistory of Western Eurasia*. H.L. Dibble and A. Montet-White (editors). The University Museum, University of Pennsylvania, Philadelphia. Pp. 255-274.

Beaudoin, A.B.
1987 Alberta radiocarbon dates 1982-1986. In: *Archaeology in Alberta 1986*, edited by M. Magne. Edmonton: Archaeological Survey of Alberta, Occasional Paper 31. Pp.197-213.

1999 What they saw: the climatic and environmental context for EuroCanadian settlement in Alberta. *Prairie Forum* 40(1):1-40.

Beckingham, J.D., Nielsen, D.G. and V.A. Futoransky.
1996 *Field guide to ecosites on the mid-boreal ecoregions of Saskatchewan.* Natural Resources of Canada, Candaian forestry Serive, Northwest Region, Northern Forestry Centre, Edmonton Alberta, Special Report 6.

Beck, C., A.K. Taylor, G.T. Jones,C.M. Fadem, C.R. Cook and S.A. Millward.
2002 Rocks are heavy: transport costs and Paleoarchaic quarry behaviour in the Great Basin. *Journal of Anthropological Archaeology* 21:481-507.

Behm, J.A.
1983 Flake Concentrations: Distinguishing Between Flintworking Activity Areas and Secondary Deposits. *Lithic Technology*, Vol. 12 (1), 9-16.

1985 An Examination of the Effects of Slope Wash on primary Deposits of Chipping Debris: A Reply to Baumler. *Lithic Technology*, Vol. 13, No. 3, 126-129.

Benedict, J.B.
1979 Getting Away From It All: A Study of Man, Mountains, and the Two Drought Altithermal. *Southwestern Lore*. 45:1-12.

Benedict, J.B. and B. L. Olson.
1978 The Mount Albion Complex: A Study of Prehistoric Man and the Altithermal*. Center for Mountain Archaeology Research Reports 1*. Ward, Colorado.

Bertorelle, G and G. Barbujani.
1995 Analysis of DNA Diversity by Spatial Autocorrelation. *Genetics*. 140:811-819.

Bierwirth, S.L.
1996 *Lithic Analysis in Southwestern France: Middle Paleolithic assemblages from the site of La Quina.* BAR International Series 663. Oxford, United Kingdom.

Binford, L.R.
1978. Dimensional analysis of behavior and site structure: Learning from an Eskimo huning stand. *American Antiquity.* 45:4-20.

Birkeland, P.W.
1984 *Soils and Geomorphology*. Oxford University Press, New York.

Bird, R. D.
1961 *Ecology of the Aspen Parkland*. Contribution No. 27, Research Station, Canada Department of Agriculture, Winnipeg, Manitoba. Research Branch, Canada Department of Agriculture, Ottawa. *Research* 29:1-32.

Bleed, P.
2001 Trees or Chains, Links or Branches: Conceptual Alternatives for Consideration of Stone Tool Production and Other Sequential Activities. *Journal of Archaeological Method and Theory*. 8(1): 101-127.

Bodu, P.
1998 Magdalenians-Early Azilians in the Centre of the Paris Basin: Affiliation? The Example of Le Colseau (Rueil-Malmaison, France). in *The Organization of*

Lithic Technology in Late Glacial and Early Post Glacial Europe. Milliken, S. (editor). BAR International Series, 700. Hadrian Books, Oxford, England. Pp. 131 - 147.

Bonnichsen, R. and C.W. Bolen.
1985 A hair, faunal, and flaked stone assemblage: a Holocene and Late Pleistocene record from False Cougar Cave, Montana In: *Woman, Poet, Scientist: essays in New World anthropology honoring Dr. Emma Lou Davis*, compiled and edited by The Great Basin Foundation. Los Altos: Ballena Press Anthropological Papers No. 29. Pp. 5-15.

Bonnichsen, R., R.W. Graham, T. Geppert, J.S. Oliver, S.G. Oliver, D. Schnurrenberg, R. Stuckenrath, A. Tratebas, and D.E. Young.
1986 False Cougar and Shield Trap caves, Pryor Mountains, Montana. *National Geographic Research* 2(3): 276-290.

Bordes, F
1969 Reflections on Typology and Technique in the Paleolithic *Arctic Anthropology* , 6(1):1-29.

Bradbury, A.P.
1998 The Examination of Lithic Artifacts from a Early Archaic Assemblage: Strengthening Inferences through Multiple Lines of Evidence, *Midcontinental Journal of Archaeology,* 23(2):263-288.

Bradbury, A. P. and P. J. Carr.
1995 Flake Typologies and Alternative Approaches on Experimental Assessment. *Lithic Technology* Vol. 20, No. 2 100-115.

Branting, S. and G. Summers.
2002 Modelling Terrain: The Global Positioning System (GPS) Survey ay Kerkenes Dağ, Turkey. *Antiquity*. 76:639-640.

Brink, J.
1978 *An Experimental Study of Microwear Formation on Endscrapers*. Archaeological Survey of Canada, Mercury Series, No. 83. Canadian Museum of Civilization, Hull, Quebec.

Brink, J. and B. Dawe.
1989 *Final Report of the 1985 and 1986 Field Season at Head-Smashed-In Buffalo Jump, Alberta.* Archaeological Survey of Alberta, Manuscript Series No. 16. Alberta Culture and Multiculturalism, Historical Resources Division. Edmonton.

Brink, J., M. Wright, B. Dawe, and D. Glaum.

1985 *Final Report of the 1983 Field Season at Head-Smashed-In Buffalo Jump, Alberta.* Archaeological Survey of Alberta, Manuscript Series No. 1. Alberta Culture, Historical Resources Division. Edmonton.

1986 *Final Report of the 1984 Field Season at Head-Smashed-In Buffalo Jump, Alberta.* Archaeological Survey of Alberta, Manuscript Series No. 9. Alberta Culture, Historical Resources Division. Edmonton.

Brown, C.T.

2001 The Fractal Dimensions of Lithic Reduction. *Journal of Archaeological Science* 28:619-631.

Brumley, J.

1975 *The Cactus Flower Site in Southeastern Alberta: 1972-1974 excavations.* Archaeological Survey of Canada, Mercury Series, Paper No. 26. Ottawa.

1988 Oldman River Dam Archaeological Project, Defined Procedural Requirements. Consultant's Report on File, Archaeological Survey of Alberta

Brumley, J.H. and C.A. Rushworth.

1983 A summary and appraisal of Alberta radiocarbon dates. In: *Archaeology in Alberta 1982*, edited by D. Burley. Edmonton: Archaeological Survey of Alberta, Occasional Paper 21: 142-160.

Bryant, L.M.

2002 A Reanalysis of the Long Creek Site: 45 Years After the Excavation: A Thesis. Unpublished M.A. Thesis, Department of Archaeology, University of Saskatchewan.

Buchner, A.P.

1979 *The 1978 Caribou Lake Project, including a summary of the prehistory of east-central Manitoba*. Winnipeg: Department of Cultural Affairs and Historical Resources, Historic Resources Branch, Papers in Manitoba Archaeology, Final Report 8.

1980 *Cultural Responses to Altithermal (Atlantic) Climate Along the Eastern Margins of the North American Grasslands 5500 to 3000 B.C.* National Museum of Man. Mercury Series, No. 197. Archaeological Survey of Canada. Ottawa.

Buchner, A.P. and L. Pujo.

1977 A preliminary report on the Whitemouth Falls site, feature No. 10-76: an Archaic burial from southeastern Manitoba. *Archae-Facts* 4(3): 26-30.

Burley, D.

1982 *Nipawin Reservoir Heritage Study, Volume 1, Resource Evaluation, Impacts and Mitigation.* SRC Publication No. C-805-5-E-82. Saskatchewan Research Council, Saskatoon.

Burley, D., J. Finnagan, O. Klimko, and J. Prentice.
1982a *Nipawin Reservoir Heritage Study Volume 2 Phase 1 Field Report and Datalog*. SRC Publication No. C-805-9-E-82. Saskatchewan Research Council, Saskatoon.

Burley, D., O. Klimko, D. Russell, D. Meyer, J. Finnagan, J. Prentice, and M. Wilson.
1982b *Nipawin Reservoir Heritage Study Volume 3 Regional Overview and Research Considerations*. Permit No. 82-10. Edited by D. Burley and D. Meyer. SRC Publication No. C-805-25-E-82. Saskatchewan Research Council, Saskatoon.

Caddy, P.S.
1883 Dominion Land Survey Map. On File at the Government of Saskatchewan Land Titles Office in Prince Albert.

Cattin, M.
1998 Raw Material Economy at the Magdalenian Sites of Hauterive-Champreveyres and Neuchatel-Monrus (Switzerland), in *The Organization of Lithic Technology in Late Glacial and Early Post Glacial Europe*. Milliken, S. (editor). Pgs 111-130. BAR International Series, 700. Hadrian Books, Oxford, England.

Chikhi, L, G. Destro-Bisol, G. Bertorelle, V. Pascali and G. Barbujani.
1998 Clines of nuclear DNA markers suggest a largely Neolithic ancestry of the European gene pool. *Proceedings of the National Academy of Sciences. USA.* 95: 9053-9058.

Christiansen, E.A.
1979 The Wisconsinan Deglaciation of southern Saskatchewan and adjacent areas. *Canadian Journal of Earth Sciences*. 16:913-938.

1982 *Quaternary Geology of the Nipawin Area, Saskatchewan*. Report on file, Saskatchewan Research Council. Report 0075-002. E. A. Christiansen Consulting Ltd, Saskatoon.

Christiansen, E. A., and E. K. Sauer.
1993 Red Deer Hill: A Drumlinized, Glaciotectonic Feature Near Prince Albert, Saskatchewan, Canada. *Canadian Journal of Earth Sciences* 30:1224-1235.

Christiansen, E.A., E. K. Sauer, and B. T. Schreiner.

1995 Glacial Lake Saskatchewan and Lake Agassiz deltas in east-central Saskatchewan with special emphasis on the Nipawin Delta. *Canadian Journal of Earth Sciences*. 32:334-348.

Clark, J.E.
1986 Another Look at Small Debitage and Microdebitage. *Lithic Technology* 15(1):21-33.

Clavelle, C.
1997 Ethnobotany of Two Cree Communities in the Southern Boreal Forest of Saskatchewan. Unpublished MA thesis. Department of Anthropology and Archaeology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

Cliff, A.D. and J.K. Ord.
1981 *Spatial Processes: Models and Applications*. Pion Limited, London, United Kingdom.

Collier, E.P.
1955 *Flood of June 1953 in the South Saskatchewan River Basin, with a section on Flood Frequencies in the Upper South Saskcatchewan River Basin.* Water Resources Paper No. 113F. Department of Northern Affairs and National Resources, Water Resources Branch. Ottawa.

Cotterell, B. amd J. Kamminga.
1979 The Mechanics of Flaking, in *Lithic Use-wear Analsysis*, B.Hayden, editor, Academic Press, New York. Pp. 97-121.

1987 The formation of flakes. *American Antiquity* 52(4):675-708.

Cotterell, B., J. Kamminga and F.P. Dickson.
1985 The essential mechanics of conchoidal flaking. *International Journal of Fracture* 29:205-221.

Crabtree, D.E.
1967 Tools used for making flaked stone artifacts: Notes on Experiments in Flint knapping: 4. *Tebiwa* 10 (1):60-73.

Crabtree, D.E.
1972 *Introduction to Flintworking, First Edition*. Idaho Museum of Natural history, Pocatello, Idaho. Occasional Papers of the Idaho Museum of Natural History, Number 28.

1982 *Introduction to Flintworking, Second Edition*. Idaho Museum of natural History, Pocatello, Idaho. Occasional Papers of the Idaho Museum of Natural History, Number 28.

Crabtree, D.E. and X. Butler

1964 Notes on experiments in flint knapping: 1. Heat treatment of silica materials. *Tebiwa* 7(1):1-6.

Crombé, P, Y Perdaen and J. Sergant.

2003 The site of Verrebroek "Dok" (Flanders, Belgium): spatial organization of an extensive Early Mesolithic settlement. *In Mesolithic on the Move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000.* Oxbow Books, Oxford. Pp. 205-215.

D'Andrea, A., R. Gallotti & M. Piperno

2002 Taphonomic interpretation of the Developed Oldowan site of Garba IV (Melka Kunture, Ethiopia) through a GIS application. *Antiquity,* 76:991–1001.

Davis, L.B. and C.L. Hill.

1995 Locating Paleoamerican occupations in S.W. Montana placered valleys. *Current Research in the Pleistocene* 12:111-113.

Davis, L.B., M. Kay, and S.T. Greiser.

1998 Barton Gulch Paleoindian Alder complex functional analysis. *Current Research in the Pleistocene* 15: 73-74.

Davis, L.B., S.A. Aaberg, and S.T. Greiser.

1988 Paleoindians in transmontane southwestern Montana: the Barton Gulch occupations, Ruby River drainage. *Current Research in the Pleistocene* 5: 9-11.

Davis, L.B., S.A. Aaberg, W.P. Eckerle, J.W. Fisher, Jr., and S.T. Greiser.

1989 Montane Paleoindian occupation of the Barton Gulch site, Ruby valley, southwestern Montana. *Current Research in the Pleistocene* 6:7-9.

Dobres, M.A.

2000 *Technology and Social Change: Outlining a Practice Framework for Archaeology.* Blackwell Publishers, Cornwall.

Doll, M.F.V.

1982 *The Boss Hill site (FdPe-4) Locality 2: pre-Archaic manifestations in the parklands of central Alberta, Canada.* Provincal Museum of Alberta Human History Occasional Paper No. 2.

Driver, J.C.

1985 Prehistoric hunting strategies in the Crowsnest Pass, Alberta. *Canadian Journal of Archaeology* 9(2):109-129.

1987 Hypsithermal paleoecology and archaeology of the Canadian Rockies. In: *Man and the Mid-Holocene Climatic Optimum*, edited by N.A. MacKinnon and G.S.L. Stuart. University of Calgary Archaeological Association. Pp. 345-360.

Druitt, T. H., and C.R. Bacon.
1986 Lithic breccia and ignimbrite erupted during the collapse of Crater Lake caldera, Oregon. *Journal of Volcanology and Geothermal Research*, 29:1-32.

Dyck, I.G.
1970 Two Oxbow Settlement Types in Central Saskatchewan. *Napao* 2(2):1-29.

1977 *The Harder Site: A Middle Period Bison Hunters' Campsite in the Northern Great Plains*. Mercury Series, No. 67, The Archaeological Survey of Canada, National Museum of Man, Ottawa.

1983 The Prehistory of Southern Saskatchewan. In *Tracking Ancient Hunters*. Saskatchewan Archaeological Society, Regina. pp. 63-139.

Dyck, I.G. and R.E. Morlan.
1995 *The Sjovold Site: a river crossing campsite in the Northern Plains*. Archaeological Survey of Canada, Mercury Series No. 151. Hull, Quebec.

Dyke, A. S., and V. K. Prest.
1987 *Paleogeography of Northern North America 18 000 - 5 000 Years Ago*. Scale 1:12,500,000, in 3 sheets. Map 1703A. Geological Survey of Canada, Ottawa, Ontario, Canada.

Ebell, S. B.
1980 The Parkhill Site: An Agate Basin Surface Collection in South Central Saskatchewan. *Pastlog No. 4*, Saskatchewan Culture and Youth, Regina.

Ellis, C. And D.B. Deller.
2000 *An Early Paleo-Indian Site Near Parkhill, Ontario*. Mercury Series, Archaeological Survey of Canada, Paper 159. Canadian Museum of Civilization, Hull, Quebec.

Ellis, J.G. and H.S. Clayton.
1970 *The Physiographic Divisions of the Northern Provincial Forest in Saskatchewan.* Saskatchewan Institute of Pedology. Publication SP3. Saskatoon.

Ens, D.A.
1998 Diachronic palaeodietary analysis of prairie fringe peoples of southeastern Manitoba. Unpublished M.A. Thesis. Department of Anthropology, University of Manitoba.

Esri

2003a Spatial Statistics Version 1.0. http://arcscripts.esri.com/details.asp?dbid=11828 , accessed November 7, 2003.

2003b Gstats. http://arcscripts.esri.com/details.asp?dbid=-1314632102, accessed October 24, 2003.

Ferring, C. R.
1984 Intrasite spatial patterning: its role in settlement-subsistence systems analysis. In *Intrasite Spatial Analysis in Archaeology*, edited by Harold J. Hietala. Cambridge University Press, London. Pp. 116-126.

Finnegan, J., D. Burley, D Meyer, P. McKeand, M. Greene, O. Klimko, and D. Russell.
1985 *Operational and Analysis Guidelines for the Archaeological Research Group*. SRC Publication E-903-17-E-85. Saskatchewan Research Council, Saskatoon.

Fladmark, K.R.
1982 Microdebitage analysis: Initial considerations. *Journal of Archaeological Science* 9:205-220.

1984 Mountain of glass: archeology of the Mount Edziza obsidian source, British Columbia, Canada. *World Archaeology* 16(2):139-156.

Forsman, M.R.A.
1972 Prince Albert National Park Archaeological Survey: 1971. Manuscript Report Number 92. National Historic Parks and sites Branch, Parks Canada, Department of Indian and Northern Affairs.

1973 The Prehistory of Montreal Lake. Unpublished M.A. thesis, Department of Anthropology and Archaeology, University of Saskatchewan.

Francis, J.
1983 Procurement and Utilization of Chipped Stone Raw Materials: A Case Study from the Bighorn Mountains and Basin of North Central Wyoming. Unpublished Ph. D. Dissertation, Department of Anthropology, Arizona State University, Tempe.

Freeman, A. and L. Roskowski.
2002 Geoarchaeology and fluvial geomorphology of the Below Forks site, Saskatchewan. *GAC-MAC Joint Annual Meeting, Saskatoon, Saskatchewan, Abstracts Volume 27.* Geological Association of Canada/Mineralogical Association of Canada. Pp. 36.

Frey, D.
1996 The Adams Collection. *Saskatchewan Archaeological Society*

Newsletter, 17(2):40-41.

1997 The Lubyk Site (FhNh-138). Saskatchewan Archaeological Society Newsletter, 18(3):56-60.

Friedman, J. and M.J. Rowlands.
1977 Notes towards an epigenetic model of the evolution of 'civilization'. In *The Evolution of Social Systems*, edited by J. Friedman and M.J. Rowlands. University of Pittsburgh Press. Pittsburgh.

Frison, G.C.
1975 Man's Interaction with Holocene Environments on the Plains. *Quaternary Research*. 5:289-300.

1978 *Prehistoric hunters of the High Plains*. Academic Press. New York, 1st edition.

1983 Stone Circles, Stone-Filled Fire Pits, Grinding Stones and High plains Archaeology. *Plains Anthropologist*. 28(2):81-91.

1991 *Prehistoric hunters of the High Plains*. Academic Press. San Diego, 2nd edition.

Frison, G. C. & Todd, L. C., (eds).
1987 *The Horner Site: The Type Site of the Cody Cultural Complex*. Academic Press, New York..

Frondell, C.
1962 *The System of Minerology of James Dwight Dana and Edward Salisbury Dana, Volume 3. Silica Minerals*. 7th Edition. John Wiley and Sons, New York.

Fuselli, S., E. Tarazona-Santos, I. Dupanloup, A. Soto, D. Luiselli, and D. Pettener.
2003 Mitochondrial DNA Diversity in South America and the Genetic History of Andean Highlanders. *Molecular Biology and Evolution*. 20(10):1682-1691.

Geary, R.
1954 The contiguity ratio and statistical mapping. *The Incorporated Statistician*, 5, 11545.

Gell, A.
1992 The technology of enchantment, in *Anthropology, Art and Aesthetics*, J. Coote and A. Shelton, editors. Claredon Press, Oxford. Pp. 40-63.

Gibson, T.H.

2001 *Site Structure and Ceramic Behaviour of a Protohistoric Cree Aggregation Campsite*, BAR series, S947, Oxford.

Gillespie, J.D.
2002 Archaeological and Geological Evidence for the First Peopling of Alberta. Unpublished MA thesis, Department of Archaeology, University of Calgary.

Gladfelter, B.G. and C.E. Tiedemann.
1985 The Continuity-Anomaly Technique for Analysis of Spatial Variation. *In For Concordance in Archaeological Analysis: Bridging Data Structure, Quantitative Technique and Theory*. C. Carr (editor) Waveland Press, Prospect Heights, Illinois. Pp. 474- 501.

Goodchild, M.F.
1986 *Spatial Autocorrelation*. CATMOG - Concepts and Techniques in Geography, no. 47. Study Group in Quantitative Methods, of the Institute of British Geographers. Geo Books, Norwich, United Kingdom.

Gordon, B.H.
1996 *People of sunlight, people of starlight : Barrenland archaeology in the Northwest Territories of Canada*. Canadian Museum of Civilization: Mercury Series No. 154, Archaeological Survey of Canada, Hull.

Goring-Morris, N., Marder, A., Davidson and F. Ibrahim.
1998 Putting Humpty Together Again: Preliminary Observations on Refitting Studies in the Eastern Mediterranean. In *The Organization of Lithic Technology in Late Glacial and Early Postglacial Europe*, edited by Sarah Milliken, BAR International Series 700, Biddles Ltd., Oxford, England. Pp. 149 - 182.

Gould, R.A.
1977 Ethno-archaeology; or, where do models come from? A closer look at Australian Aboriginal lithic technology. In *Stone tools as cultural markers: change, evolution and complexity.* R.V.S. Wright (editor). Australian institute of Aboriginal Studies, Canberra, Australia. Prehistory and Material Culture Series No. 12. Pp. 162-168.

1980 *Living Archaeology.* Cambridge University Press, London.

Gould, R. A. and S. Saggers.
1985 Lithic procurement in central Australia: a closer look at Binford's idea of embeddedness in archaeology. *American Antiquity* 50:117-136.

Grasby, E., E. M. Gryba, and R. K Bezys.
2002 A Bedrock Source of Swan River Chert. *Plains Anthropologist* 47:275-283.

Green, D.
1998 A Re-evaluation of the Oxbow Dam Site (DhMn-1): middle holocene cultural continuity on the Northern Plains. Unpublished M.A. Thesis, Department of Archaeology, University of Saskatchewan.

Greiser, S.T., T.W. Greiser, and S.M. Vetter.
1985 Middle prehistoric period adaptations and paleoenvironment in the northwestern Plains: the Sun River site. *American Antiquity* 50: 849-877.

Gryba, E.M.
1974 Final Report of the 1973 Archaeological Survey of Prince albert National park: Findings and Recommendations. QS-7090-037-EE-A1. Manuscript Repost Number 319. Parks Canada, History and Archaeology.

1976 The early side-notched component at site DjOn-26. In: *Archaeology in Alberta 1975*, edited by J.M. Quigg and W.J. Byrne. Edmonton: Archaeological Survey of Alberta, Occasional Paper 1: 92-107.

Gunn, J., Mahula, R. and J.B. Sollberger.
1976 The Sollberger Distribution: analysis and applications of a tool reduction sequence. *La Tierra* 3: 2-8.

Hamlin, W.K. and J.D. Howard.
1975 Exercises in Physical Geography. 4th edition. Burgess Press, Minneapolis.

Hartwell, B.
2002 A Neolithic ceremonial timber complex at Ballynahatty, Co. Down Antiquity. 76:526-532.

Head, T.
1987 Archaeological resource assessments, Jasper National Park. *Parks Canada, Microfiche Report Series No. 341*.

Hemmings, E. T.
1987 The Horner Site Debitage. In *The Horner Site: The Type Site of the Cody Cultural Complex*, G. C. Frison and L. C. Todd (editors). Pp. 435-442. Academic Press, New York.

Henry, D.O., C.V. Haynes, and B. Bradley
1976 Quantitative variations in flaked stone debitage. *Plains Anthropologist* 21:57-61.

Hester, T.R.

1972 Ethnographic evidence for the thermal alteration of siliceous stone. *Tebiwa* 15(2):63-65.

Hiscock, P.
2002 Quantifying the Size of Artifact Assemblages, *Journal of Archaeological Science*, 29, 251-258.

Hjermstad, B.
1992 Have You Seen One of These? On the trail of the elusive hafted spokeshave. *Saskatchewan Archaeological Society Newsletter*, 13(1):12.

1996 The Fitzgerald Site: A Besant Pound and Processing Area on the Northern Plains. Unpublished M.A. Thesis. Department of Anthropology and Archaeology, University of Saskatchewan.

2001 The Stuart lake Site Report. Manuscript on File at the Saskatchewan Heritage Branch, Regina.

Hodder, I.
1982 Towards a Contextual Approach to Prehistoric Exchange. In Contexts for Prehistoric Exchange. J.E. Ericson and T.K. Earle (editors). Academic Press, New York. Pp. 199-211.

Hodder, I and C. Orton.
1976 *Spatial analysis in archaeology*. Cambridge University Press Cambridge.

Hogg, E. H.
1994 Climate and the Southern Limit of the Western Canadian Boreal Forest. *Canadian Journal of Forest Research* 24:1835-1845.

1997 Temporal Scaling of Moisture and the Forest-Grassland Boundary in Western Canada. *Agricultural and Forest Meteorology* 84:115-122.

1999 Simulation of Interannual Responses of Trembling Aspen Stands for Climatic Variation and Insect Defoliation in Western Canada. *Ecological Modelling* 114:175-193.

Hogg, E. H., and P. A. Hurdle.
1995 The Aspen Parkland in Western Canada: A Dry-climate Analogue for the Future Boreal Forest? *Water Air and Soil Pollution* 82:391-400.

Hogg, E. H., B. Saugier, J. Pontailler, T. A. Black, W. Chen, P. A. Hurdle, and A. Wu.
2000 Responses of Trembling Aspen and Hazlenut to Vapor Pressure Deficit in a Boreal Deciduous Forest. *Tree Physiology* 20:725-734.

Hogg, E. H., and A. G. Schwartz.
1999 *Tree-ring Analysis of Declining Aspen Stands in West-Central Saskatchewan*. Information Report NOR-X-359. Northern Forestry Centre, Canadian Forest Service, Natural Resources Canada, Edmonton.

Holen, S.R.
1991 Bison hunting Territories and Lithic Acquisition among the Pawnee: An Ethnohistoric and Archaeological Study. In *Raw Material Economies among Prehistoric Hunter-Gatherers*. A. Montet-White and S. Holen Eds. University of Kansas Publications in Anthropology 19. University of Kansas Press, Lawrence. Pp. 399-411.

Houston C.S. and M.G. Street.
1957 *The Birds of the Saskatchewan River. Carlton to Cumberland.* Special Publications No. 2 Saskatchewan, Natural History Society, Regina.

Hughes, T.
1998 *Birthday letters*. Faber and Faber. London.

Hurt, W. R.
1966 The Altithermal and the Prehistory of the Northern Plains. *Quaternia* 8:101-113.

Husted, W.M.
1969 Bighorn Canyon Archeology. *Smithsonian Institution, River Basin Surveys, Publications in Salvage Archeology No. 12.*

2002 *The Archeology of Mummy Cave, Wyoming: An Introduction to Shoshonean Prehistory*. United States Department of the Interior, National Park Service, Midwest Archaeological Center. Lincoln, Nebraska.

Johnson, E. A.
1986 Properties and Sources of Some Saskatchewan Lithic Materials of Archaeological Significance. Unpublished M.A. Thesis, Department of Archaeology, University of Saskatchewan.

1994 A Cache of Quartzite Artifacts from the Shores of Lake Diefenbaker. Saskatchewan Archaeological Society Newsletter. 15(5):80-82.

Johnson, I.
1984 Cell frequency recording and analysis of artifact distributions. In, *Intrasite Spatial analysis in Archaeology*, Harold J. Hietala, editor. Cambridge University Press. London. Pp. 75-96.

Kasstan, S.C.

2003 The East Village Access Site: A Re-examination. Manuscript on File at Parks Canada, Western Canada Resource Centre, Winnipeg. Archaeological Library.

Keeley, L.H.
1980 *Experimental determination of stone tool uses*. Chicago: University of Chicago Press.

Kehoe, A. B.
1978 Francois' House: An Early Fur Trade Post on the Saskatchewan River. Saskatchewan Culture and Youth, Regina, *Pastlog*, No. 2.

Keyser, J.D. and J. L. Fagan.
1993 McKean Lithic Technology at Lightning Spring. *Plains Anthropologist Memoir,* No 27. 38:37-51.

Klassen, R. W.
1989 Quaternary Geology of the Southern Canadian Interior Plains. In *Quaternary Geology of Canada and Greenland*. Volume also published as Geological Society of America, The Geology of North America, Vol. K-1, edited by R. J. Fulton, pp. 138-173. Geology of Canada No. 1. Geological Survey of Canada.

Klimko, O.
1985 *Nipawin Reservoir Heritage Study Volume 7 The Gravel Pit and Eastcott Flat Sites: Final Excavation Reports*. Permit Nos. 82-10 and 83-11. Edited by D. Meyer. SRC Publication No. E-903-8-E-85. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada.

Knecht, K.
1997 Projectile Points of Bone, Antler and Stone: Experimental Exploration of Manufacture and Use. In *Projectile Technology*. H. Knecht (editor) Plenum Press, New York. Pp. 191-212.

Kobayashi, H.
1975 The Experimental Study of Bipolar Flakes. In *Lithic Technology: Making and Using Stone Tools.* E. Swanson (editor). Mouton Publishers, Paris. Pp. 115-128.

Kogawa, J.
2003 A Garden of Anchors, Selected Poetry. Mosaic Press, Oakville, Ontario.

Kooyman, B.P.
2000 *Understanding Stone Tools and Archaeological Sites*. University of Calgary Press, Calgary.

Kozak, L.M., Crosson, L.S., H.B. Stonehouse

1968a *Soil Survey of the James Smith Indian Reserve No. 100 (Saskatoon District).* Publication S154, Saskatchewan Institute of Pedology, Department of Soil Science, University of Saskatchewan, Saskatoon.

1968b *Soil Survey of the Cumberland Indian Reserve No. 100 (Saskatoon District).* Publication S155, Saskatchewan Institute of Pedology, Department of Soil Science, University of Saskatchewan, Saskatoon, Saskatchewan.

Kuhn, S.L.
1995 *Mousterian Lithic Technology: An Ecological Perspective*. Princeton University Press, Princeton, N.J.

Kuigt, I., W. C. Prentiss, and D.L. Pokotylo.
1995 Bipolar Reduction: An experimental study of debitage variability. *Lithic Technology*. 20(2):116-127.

Kvamme, K.L.
1990 Spatial Autocorrelation and the Classic Maya Collapse Revisited: refined techniques and new conclusions. *Journal of Archaeological Science*. 17:197-207.

1996 Investigating Chipping Debris Scatters: GIS As an Analytical Engine. In *New Methods, Old Problems, Geographic Information Systems in Modern Archeological Research.* D.G. Herbert (editor) Maschner. Center for Archaeological Investigations, Southern Illinois University of Carbondale, Occasional Paper No. 23. Pp. 38-74.

Lahren, L.A.
1976 *The Myers-Hindman site: an exploratory study of human occupation patterns in the Upper Yellowstone valley from 7000 B.C. to A.D. 1200*. Livingston: Anthropologos Researches International Incorporated.

Lamers, L.
1988 *Flood Frequencies in the South Saskatchewan River Basin.* Technical Report C. 5. Canadian-Saskatchewan South Saskatchewan River Basin Study Board. Saskatchewan Water Corporation and Environment Canada. WPM-WNR-1988-09. Regina.

LeBlanc, R.
1992 Wedges, Pièces esquillées, Bipolar Cores and Other Things: An Alternative to Shott's View of Bipolar Industries. *North American Anthropologist*, 13: 1-14.

Leighton, A. L.

1985 *Wild plant use by the Woods Cree : Nihithawak, of east-central Saskatchewan*. Canadian Ethnology Service Paper No. 101. Canadian Ethnology Service, National Museums of Canada, National Museum of Man, Ottawa.

Leonoff, L.M.
1970 The Identification, Distribution and Sources of Lithic raw Materials in Manitoba Archaeological Sites. Unpublished M.A. Thesis. Department of Anthropology, University of Manitoba.

Leudtke, B.E.
1992 *An Archaeologist's Guide to Chert and Flint.* Institute of Archaeology, Archaeological Research Tools 7. University of California, Los Angeles.

Lindgren, C.
2003 My way or your way. On the social dimension of technology as seen in lithic strategies in eastern middle Sweden during the Mesolithic. In *Mesolithic on the Move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000.* Oxbow Books. Oxford. Pp. 177-183.

Loeffler, D.
2003 Some observations concerning the relationship between distribution patterns, floor size and social organization. In *Mesolithic on the Move: Papers presented at the Sixth International Conference on the Mesolithic in Europe, Stockholm 2000.* Oxbow Books, Oxford. Pp. 238-248.

Logan, B. and M.E. Hill, Jr.
2000 Spatial Analysis of Small Scale Debris from a Late Prehistoric Site in Lower Missouri Valley, Kansas. Journal of Field Archaeology, 27:241-256.

Lovick, S.K.
1983 Fire-Cracked Rock as Tools: Wear Pattern Analysis. *Plains Anthropologist*, 28(1):41-52.

Low, B.D.
1995a A Blade-like Lithic Component at the Armit River Site (FeMk-1) in East-Central Saskatchewan. *Saskatchewan Archaeological Society Newsletter*, 16(2):16-20.

1995b Lithic Technology at the Armit River Site (FeMk-1) - Part 2: A Burin-like Component. *Saskatchewan Archaeological Society Archaeological Newsletter* 16(4):62-65.

1995c Lithic Technology at the Armit River Site (FeMk-1) - Part 3: Microliths. *Saskatchewan Archaeological Society Archaeological Newsletter* 16(5):95-97.

1996 Swan River Chert. *Plains Anthropologist*. 41:165-174.

1997 Bipolar Technology and Pebble Stone Artifacts: Experimentation in Stone Tool Manufacture. Unpublished M.A. Thesis, Department of Anthropology and Archaeology, University of Saskatchewan.

Loy, T. And G.R. Powell.
1977 *Archaeological Data Recording Guide*. British Columbia Provincial Museum Heritage Record No. 3. B.C. Provincial Museum, Victoria.

Lunn, K.
1987 East Village Access Road and Parking Lot, by Kevin Lunn; Fieldwork by Peter Nieuwhof, in *Batoche National Historic Park Archaeological Research, 1984, contributions by Ellen Lee, Douglas Proch, Virginia Locket and Peter Nieuwhof.* K. Lunn and E. Lee (eds.), Microfiche Report Series, No. 388, Pp. 59. Environment Canada – Parks. Ottawa.

Lyman, R.L.
1994 V*ertebrate Taphonomy*. Cambridge University Press, Cambridge.

MacDonald, G.F.
1968 Debert, a Paleo-Indian Site in Central Nova Scotia*. National Museum of Canada, Anthropological Paper 16.*

Magne, M.P.R.
1985 Lithics and Livelihood: Stone Tool Technologies of Central and Southern Interior British Columbia. *National Museum of Man, Mercury Series No. 133*. Ottawa.

2001 Debitage Analysis as a Scientific Tool for Archaeological Knowledge. , in *Lithic Debitage: context, form and meaning.* W. Andrefsky (editor). University of Utah Press, Salt Lake City, Pp. 21-30.

Mandeville, M.D.
1973 A consideration of the thermal pretreatment of chert. *Plains anthropologist* 18(61):177-202.

Mandeville, M.D. and J.J. Flenniken
1974 A Comparison of the flaking qualities of Nehawka chert before and after thermal pretreatment. *Plains Anthropologist* 19 (64):146-148.

Marles, R.J., T. Clavelle, L. Monteleone, N. Tays and D. Burns.
1999 *Aboriginal plant use in Canada's northwest boreal forest.* Natural Resources of Canada and Canadian Forest Service, Vancouver, UBC Press.

McCary, B.C.

1975 The Williamson Paleo-Indian Site, Dinwiddie County, Virginia. *Chesopiean* 13:47-131.

MacDonald, G.F.
1968 *Debert: A Palaeo-Indian Site in Central Nova Scotia*. National Museum of Canada, Anthropology Papers, No. 16. Ottawa.

Mandelbrot, B.
1967 How Long is the Coast of Britian? Statistical Self-Similarity and Fractional Dimension. *Science.* 156:636-638.

Meltzer, D.
1999 Human Responses to Middle Holocene (Altithermal) Climates on the North American Great Plains. *Quaternary Research*. 52:404-416.

Meyer, D.
1983 *Nipawin Reservoir heritage study. Volume 6. 1982 final excavations : The Permanent Camp, Minnie and Lloyd sites*. SRC Publication No. E-903-6-E-83. Saskatchewan Research Council, Saskatoon.

1985 A component in the Scottsbluff Tradition: Excavations at the Niska Site *Canadian Journal of Archaeology* 9(1):1-38.

1990 *Test Excavations at the Below Forks Site (FhNg-25), 1989*. Permit 88-60. Manuscript on File at the Saskatchewan Heritage Branch, Regina.

2001 Excavations at the Below Forks Site: the 2000 Season Interim Report. Manuscript on file at the Saskatchewan Heritage Branch, Regina.

2002a Excavations at the Below Forks site: the 2001 Season Interim Report. Manuscript on file at the Saskatchewan Heritage Branch, Regina.

2002b 2002 End-of-Field Season Report. Saskatchewan River Forks Region. Manuscript on File at the University of Saskatchewan.

Meyer, D. and J. Carter.
1978 Archaeological Research in the Gronlid Ferry Area. Saskatchewan Research Council. SRC Publication C-78-13.

Meyer, D. and H.T. Epp.
1990 North-South Interaction in the Late Prehistory of Central Saskatchewan. *Plains Anthropologist*. 35:321-342.

Meyer, D. and O. Klimko.

1986 *The James Smith Archaeological Survey*. Saskatchewan Research Council, SRC Publication No. E-903-5-E-86.

Meyer, D, J. Wilson, and O. Klimko.
1981 *Archaeological mitigation along the Key Lake access road* Saskatchewan Research Council. SRC publication, no C-805-11-E-81.

Michlovic, M.G.
1996 Archaeological Excavations at the Rustad Site. In *Quaternary Geology of Southern Lake Agassiz Basin.* Guidebook and Miscellaneous Short Papers for: Midwest Friends of the Pleistocene 43rd Annual Meeting, May 31 - June 2, 1996 & Post Meeting Fieldtrip June 2-3, 1996. K.L. Harris, M.R. Lutl and J.R. Reid (editors). North Dakota Geological Survey Miscellaneous Series 82.

Miles, B.C. and W.W. Sawchyn.
1988a *Hydrological Drought Analysis of Simulated Flows South Saskatchewan River Basin. Technical Report c.6.* Saskatchewan Fisheries Laboratory, Saskatchewan Parks, Recreation and Culture, Saskatoon, SK, prepared for Canada-Saskatchewan South Saskatchewan River Basin Study Board. Saskatchewan Water Corporation and Environment Canada.

1988b *Fishery Survey of the South Saskatchewan River and its Tributaries in Saskatchewan, Technical Report d.8.* Saskatchewan Fisheries Laboratory, Saskatchewan Parks, Recreation and Culture, Saskatoon, SK, prepared for Water Quality Technical Committee, Canada-Saskatchewan South Saskatchewan River Basin Study. Saskatchewan Water Corporation and Environment Canada.

Miller, J.F.V.
1981 Mortuary Practices of the Oxbow Complex. *Canadian Journal of Archaeology* 5:103-117.

Milliken, S. (editor).
1998 *The Organization of Lithic Technology in Late Glacial and Early Post Glacial Europe.* BAR International Series, 700. Hadrian Books, Oxford, England.

Moorhouse, W.N.
1959 *The Study of Rocks in Thin Section.* Harper and Row Publishers, New York.

Moran, P.
1948 The interpretation of statistical maps. *Journal of the Royal Statistical Society* B 10, 24341.

Morlan, R.

2003 *Canadian Archaeological Radiocarbon Database.* http://www.canadianarchaeology.com/radiocarbon/card/dbase.htm, accessed October 21, 2003.

Morlan, R.E., R. McNeely, and E. Nielsen.
2000 *Manitoba radiocarbon dates*. Manitoba Geological Survey, Open File Report OF2000-1.

Mulloy, W.
1954 The McKean Site in Northeastern Wyoming. *Southwestern Journal of Anthropology.* 10:432-460.

1958 A Preliminary Historical Outline for the Northwestern Plains. *University of Wyoming Publications* 1:233-264.

Mustapha, A.M., S. Figliuzzi, H. Richert and G. Coles.
1981 *History of Floods In the North Saskatchewan River Basin*. Alberta Environment, Environmental Engineering Support Serives, Technical Services Division.

Nehik, S.C.
1986 The effects of trade on resource procurement behaviour: A late prehistoric example from the Southern Plains. *Plains Anthropologist* 31:141-154.

Nelson, S.M., M. Plooster, and D.L. Ford.
1987 An Interactive Computer Graphic Technique for Identifying Occupation Surfaces in Deep Archaeological Sites. Journal of Field Archaeology, 14:353-358.

Newton, D.
1985 Site 48SW3039 Locality A: a multiple component Archaic period hunter-and-gatherer campsite in southwest Wyoming. *Journal of Intermountain Archaeology* 4(1): 47-61.

Nieuwhof, P.
1987 Archaeological Research at Batoche National Historic Site, 1985. *Research Bulletin,* No. 254, Environment Canada – Parks, Ottawa.

Novecosky, B.J.
2002 Archaeological Investigation in the Quill Lakes Region of East Central Saskatchewan, Unpublished M.A. Thesis, Department of Archaeology, University of Saskatchewan.

Odell, G.

1999 Uwharries Lithic Research Conference 1999 Keynote Address. *http://www.arch.dcr.state.nc.us/uwharrie/odell26pm.html.* Accessed November 11, 2003.

Overstreet, D.F.
1993 *Chesrow: A Paleoindian Complex in the Southern Lake Michigan Basin.* Case Studies in Great Lakes Archaeology, No. 2. Great Lakes Archaeological Press, Milwaukee, Wisconsin.

Parker, S.P. (editor)
1997 *McGraw-Hill Dictionary of Earth Sciences.* McGraw-Hill, Toronto.

Patrick, D.
1883 Dominion Land Survey Map. On File at the Government of Saskatchewan Land Titles Office, Prince Albert.

Patterson, J.R.
1975 Selective heat treating of flint. *Texas Archaeology* 19(3):10-11.

Paz, Octavio
1987. The Collected Poems of Octavio Paz, 1957-1987. New Directions Publishing Corp. New York.

Pearce, G and P. Gullov.
1996 *Saskatchewan Stone: Preliminary Investigations*, by. Miscellaneous Report 96-6, Saskatchewan Energy and Mines: Industrial Minerals Branch, Regina

Pelcin, A.
1997a The effect of indentor type on flake attributes: evidence from a controlled experiment. *Journal of Archaeological Science* 24:613-621.

1997b The formation of flakes: the role of platform thickness and exterior platform angle in the production of flake initiations and terminations. *Journal of Archaeological Science* 24:1107-1113.

Pentland, R.S.
1988 *Hydrological Drought Analysis of Simulated Flows, South Saskatchewan River Basin.* Technical Report C.6. Canada-Saskatchewan South Saskatchewan River Basin Study. Saskatchewan Water Corporation and Environment Canada. Prepared by Water Resource Consultants Ltd., Regina.

Pettipas, L.
1996 *Archaeological Migrations: A History of Movements in Southern Manitoba.* Manitoba Museum of Man and Nature. Winnipeg.

Pickard, R.

1987 Archaeological resource description, Canadian National Railway Corridor, Jasper National Park. *Parks Canada, Microfiche Report Series No.* 337.

Pipe, A.E. (ed).

1982 *Environmental Baseline Study of the Saskatchewan River,Saskatchewan, in the Vicinity of Choiceland and the Forks'*. 2 Volumes. SRC Publication No. C- 805-25-E-80. Sakatchewan Research Council, Saskatoon.

Piper, R.G., I. B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, J.R. Leonard.

1982 *Fish Hatchery Management*. American Fisheries Society. Bethesda, Maryland.

Plath, S.

1981 *The collected poems*. Harper and Row, New York.

2000 The journals of Sylvia Plath, 1950-1962. Faber and Faber, London.

Porter, J., K. Dilts, D. Fedje, I. Sumpter, and R. Pickard.

1988 Environment Canada, Parks archaeology in Alberta, 1987. In *Archaeology in Alberta 1987*, edited by M. Magne. Edmonton: Archaeological Survey of Alberta, Occasional Paper No. 32. Pp. 135-157.

Prentice, J., J. M. Quigg, and D. Meyer.

1983 *Nipawin Reservoir Heritage Study Volume 6 1982 Final Excavations: The Permanent Camp, Minnie and Lloyd Sites*. Permit No. 82-10. Edited by D. Meyer. SRC Publication No. E-903-6-E-83. Saskatchewan Research Council, Saskatoon.

Prentice, J.

1983 The Tschetter site: a study of a late prehistoric bison kill. Unpublished M.A. Thesis, Department of Anthropology and Archaeology, University of Saskatchewan.

Proch, D.

1986 Archaeological Research at Batoche National Historic Site, 1984. *Research Bulletin,* No. 245, Environment Canada – Parks, Ottawa.

Purdy B.A.

1974 Investigations concerning the thermal alteration of silica materials: an archaeological approach. *Tebiwa* 17(1):37-66.

1975 Fractures for the Archaeologist. In *Lithic Technology: Making and Using Stone Tools.* Swanson, E. (editor). Mouton Publishers, Paris. Pp. 133-144.

Purdy, B.A. and H.K. Brooks
1971 Thermal alteration of silica minerals: an archaeological approach. *Science* 173:322-325.

Quigg, J.M.
1984 A 4700 Year Old Tool Assembalge from East Central Alberta. *Plains Anthropologist*, 29(104):151-153.

1986 *Nipawin Reservoir Heritage Study Volume 8 The Crown Site (FhNa-86) Excavation Results*. Permit Nos. 82-10 and 84-19. Edited by D. Meyer. SRC Publication No. E-903-7-E-86. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada.

Rankama, T.
1997 *Ala-Jalve: Spatial, technological, and behavioral analyses of the lithic assemblage from a Stone Age-Early Metal Age site in Utsjoki, Finnish Lapland*. BAR International Series 681. Oxford, England.

Reed, E.B.
1962 *Limnology and Fisheries of The Saskatchewan River in Saskatchewan*. Fisheries Report No. 4., Fisheries Branch, Department of Natural Resources, Province of Saskatchewan.

Reeves, B.O.K.
1972 *The archaeology of Pass Creek valley, Waterton Lakes National Parks* Ottawa: National Historic Sites Service, Manuscript Report 61, 2 volumes.

1973 The Concept of the Altithermal Cultural Hiatus in Northern Plains Prehistory. *American Anthropologist*. 75:1221-1253.

1974a *Crowsnest Pass archaeological project, 1972 salvage excavations and survey paper no. 1, preliminary report*. Ottawa: National Museum of Man, Archaeological Survey of Canada, Mercury Series Paper No. 19.

1974b *Crowsnest Pass archaeological project, 1973 salvage excavations and survey paper no. 2*, preliminary report. Ottawa: National Museum of Man, Archaeological Survey of Canada, Mercury Series Paper No. 24.

1978 Head-Smashed-In: 5500 years of bison jumping in the Alberta plains. In: Bison Procurement and Utilization: a symposium. L.B. Davis and M. Wilson (editors). *Plains Anthropologist Memoir* 14: 151-174.

Reeves, B.O.K. and J. Dormaar.
1972 A partial pedological and archaeological report from the southern Alberta Rocky Mountains. *Arctic and Alpine Research* 4:325-336.

Renfrew, C.
1975 Trade as Action at a Distance: Questions of Integration and Communicaiton. In Ancient Civilization and Trade, edited by J.A. Sabloff and C.C. Lamberg-Karlovsky. University of New Mexico Press, Albuquerque. Pp. 3-59.

Richardson, J.
1829 *Fauna boreali-americana: or, The Zoology of the northern parts of British America, containing descriptions of the objects of natural history collected on the late northern land expeditions, under command of Captain Sir John Franklin. Part One - The quadrupeds.* Published under the authority of the Right Honourable the Secretary of State for Colonial Affairs, John Murray, London. (sold in London by Longman, Orme, Brown, Green, & Longmans). [Copy kept at University of Saskatchwan Library, Special Collections].

Riel-Salvatore, J., M. Bae, P. McCartney & A. Razdan.
2002 Palaeolithic archaeology and 3D visualization technology: recent developments. *Antiquity,* 76:929–30

Rowe, J. S.
1972 *Forest Regions of Canada*. Canadian Forestry Service, Publication No. 1300. Department of Environment, Ottawa.

Runge, W.
1993 *The Long Tailed Weasel in Saskatchewan. Wildlife Technical Report 93-3*. Saskatchewan Environment and Resource Management, Wildlife Branch, Prince Albert.

Runge, W. and J. Mulhern.
1985 *The Status of Wild Furbearers in Saskatchewan*. Saskatchewan Parks and Renewable Resources, Wildlife Branch. Prince Albert.

Running, G.L. IV.
1995 Archaeological Geology of the Rustad Quarry Site (32RI775): An Early Archaic Site in Southeastern North Dakota. *Geoarchaeology*, 10(3): 183-204.

Rutherford, J.S.
2002 Slope Sediments and landscape evolution in Wanuskewin Heritage Park, Saskatoon, Saskatchewan: A geoarchaeological interpretation. *GAC-MAC Joint Annual Meeting, Saskatoon, Saskatchewan, Abstracts Volume 27.* Geological Association of Canada/Mineralogical Association of Canada. Pp. 103.

Saskatchewan Department of Natural Resources.
1938 *The Mineral Resources of Saskatchewan*. King's Printer, Regina.

Saskatchewan Power Corporation.
1980 The Map File of the Forks Survey. Notarized Topographic Maps on File at the Royal Saskatchewan Museum Annex, Regina.

Sawchyn, W.W.
1973 *Assessment of the Effect of Effluent from the Prince Albert Pulp Mill on Bottom Fauna and Sediments of the North Saskatchewan River and Tobin Lake*. Chemistry Division, Saskatchewan Research Council, SRC C-73-1.

Schreiner, B.T.
1983 Lake Agassiz in Saskatchewan. In *Glacial Lake Agassiz*, J.T. Teller and L. Clayton (editors). Geological Association of Canada, Special Paper 26. Pp. 75-96.

Schwab-Moe, B.
1987 *A Floristic Study of the Fort a la Corne Area, Central Saskatchewan*. Unpublished M.A. thesis. Freien Universitat Berlin, Berlin, Germany.

Sellet, F.
1993 Chaîne Opératiore: The Concept and Its Application. *Lithic Technology* 18:106-112.

Semenov, S.A.
1966 *Prehistoric Technology*. Barnes and Noble, Inc. New York.

Shay, C.T.
1971 *The Itasca Bison Kill Site: An Ecological Analysis.* Minnesota Historical Society.

Sheehan, M. S.
1994 Cultural Responses to the Altithermal: The Role of Aquifer-Related Water Resources. *Geoarchaeology,* 9(2):113-137.

1995 Cultural Responses to the Altithermal or Inadequate Sampling. *Plains Anthropologist*, 40(153):261-270.

2002 Dietary Responses to Mid-Holocene Climatic Change. *North American Archaeologist*, 23(2):117-144.

Shott, M.J.
1989 Bipolar Industries: Ethnographic Evidence and Archaeological Implications. *North American Archaeologist* 10: 1-24.

1994 Size and form in the Analysis of Flake Debris: Review and Recent Approaches. In the *Journal of Archaeological Method and Theory*, 1(1):69-110.

Silva, R.J.
1997 *Introduction to the Study and Analysis of Flaked Stone Artifacts and Lithic Technology.* Centre for Desert Archaeology, Tucson, Arizona.

Simpson, M.A., M. J. Millard and D. Bedard.
1990 *Geological and Remote Sensing Investigarion of the Prince Albert - Shellbrook Area, Saskatchewan.* Saskatchewan Research Council. Saskatoon. SRC Publication R-1200-2-E-90.

Smith, C.G.
2003 *Historical and Present Location of Lake Sturgeon (Acipenser fulvescens) in Saskatchewan.* Canadian Plains Research Centre and Saskatchewan Envirnoment, Fish and Wildlife Technical Report 2003-2. Saskatchewan Environment Fish and Wildlife Branch, Saskatoon.

Snell, D.E.
1991 *Fish Species Distribution in Saskatchewan*. Saskatchewan Parks and Renewable Resources, Fisheries Branch. Regina.

Sollberger, J.B.
1994 Hinge Fracture Mechanics. *Lithic Technology* 19:17-20.

Spikins, P, C. Conneller, H. Ayestaran and B. Scaife.
2002 GIS Based Interpolation Applied to Distinguishing Occupation Phases of Early Prehistoric Sites. *Journal of Archaeological Science* 29:1235-1245.

Stahle, D.W. amd J. E. Dunn.
1982 An Analysis and Application of the Size Distribution of Waste Flakes from the Manufacture of Stone Tools. *World Archaeology.* 14:84-97.

Steffen, A., and E. Skinner and P. Ainsworth.
1998 A View to the Core: Technological Units and Debitage Analysis, In *Unit Issues in Archaeology: Measuring Time. Space, and Material*, A.F. Ramenofsky and A. Steffen (editors). The University of Utah Press, Salt Lake City. Pp. 131 - 146.

Stevenson, M.G.
1985 The Formation of Artifact Assemblages at Workshop/Habitation Sites: Models from Peace Point in Northern Alberta. *American Antiquity*, 50(1):63-81.

Stevenson, T.
1992 Chipped Stone Tools from EgNq-18. Saskatchewan Archaeological Society Newsletter, 13(5).

Sullivan, A. P. And K. C. Rozen.
1985 Debitage analysis and archaeological interpretation. *American Antiquity* 50(4)755-779.

Sundstrom, L.
1989 Culture History of the Black Hills with Reference to Adjacent Areas of the Northern Great Plains. *Reprints in Anthropology* 40. J & L. Reprint, Lincoln, Nebraska.

Swanson, E. (editor).
1975 Lithic Technology: Making and Using Stone Tools. Mouton Publishers, Paris.

Tobler, W.R.
1974 Spatial autocorrelation and the archaeologist. Introductory comments presented to the Society for American Archaeology, Washington DC., May 2, 1974.http://www.geog.ucsb.edu/~tobler/publications/pdf_docs/archaeology/Archaeology.pdf, accessed November 8, 2003.

Tsirk, A.
1979 Regarding Fracture Initiations. In Lithic Use-wear Analysis, B. Hayden (ed.). Academic Press, New York. Pp. 83-96.

Turcotte, D.L.
1986 Fractals and Fragmentation. *Journal of Geophysical Research*. 91:1921-1926.

Valentine, K.W.G., K.R. Fladmark, and B.E. Spurling.
1980 The description, chronology and correlation of buried soils and cultural layers in a terrace section, Peace River valley, British Columbia. *Canadian Journal of Soil Science* 60: 185-197.

Van Dyke, S. and S. Stewart.
1985 *Hawkwood site (EgPm-179): a multicomponent prehistoric campsite on Nose Hill.* Edmonton: Archaeological Survey of Alberta, Manuscript Series 7: 225 pp.

Van Dyke, S., S. Hanna, W. Unfreed, and B. Neal.
1991 That dam archaeology: campsites archaeology in the Oldman River reservoir. In: *Archaeology in Alberta 1988 and 1989*, edited by M. Magne. Edmonton: Archaeological Survey of Alberta, Occasional Paper No. 33: 25-65.

Vance, R. E., A. B. Beaudoin and B. H. Luckman.
1995 The Paleoecological Record of 6 ka BP Climate in the Canadian Prairie Provinces. Géographie physique et Quaternaire 49:81-98.

Vasiliev, I.R.
1996 Visualization of Spatial Dependence: An Elementary View of Spatial Autocorrelation. In *Practical Handbook of Spatial Statistics*, S. L. Arlinghaus (editor). CRC Press, New York.

Verrey, R.
1981 Heat Treatment of Flint Run Jasper. *Flintknappers Exchange*, 4(2):14-17.

Villa, P.
1983 *Terra Amata and the Middle Pleistocene Archaeological Record of Southern France.* University of California Press, Berkeley.

Walker, E. G.
1992 *The Gowen Sites, Cultural Responses to Climatic Warming on the Northern Plains (7500-5000 B.P.)* Archaeological Survey of Canada, Mercury Series Paper 145. Canadian Museum of Civilization, Hull, Quebec.

Wedel, W.
1961 Prehistoric Man on the Great Plains. University of Oklahoma Press, Norman.

Weir, J. M. H., and E. A. Johnson.
1998 Effects of Escaped Settlement Fires and Logging on Forest Composition in the Mixedwood Boreal Forest. *Canadian Journal of Forest Research* 28:459-467.

Western Canadian Archaeological Council.
1960 The Present State of Archaeology in Western Canada. Western Canadian Archaeological Council: Proceedings No. 1: Glenbow Foundation, Calgary (edited and mimeographed by the Museum of the Plains Indian, Browning Montana).

Whallon, R.
1984 Unconstrained clustering for the analysis of spatial distributions in archaeology, in *Intrasite Spatial Analysis in Archaeology*. H. J. Hietala (editor) Cambridge University Press, London. 242-277.

Wheatley, D. and M. Gillings.
2002 *Spatial Technology and Archaeology: The archaeological applications of GIS*. Taylor and Francis Inc. New York.

Whitley, D.S. and W.A.U. Clark.
1985 Spatial Autocorrelation Tests and the Classic Maya Collapse: Methods and Inferences. *Journal of Archaeological Science* 12:377-395.

Wilson, I.R.
1987 Excavations at FhQl 29, Jasper National Park. *Parks Canada, Microfiche Report Series No. 316*.

Wilson, J.S.
1982 Archaeology and History. In *Environmental Baseline Study of the Saskatchewan River in the Vicinity of Choiceland and the Forks*. H.E. Pipe, editor. Saskatchewan Research Council. SRC pub. C-805-25-E-80. pages 743-973.

Wilson, M.C.
1983 *Once upon a river: archaeology and geology of the Bow River valley at Calgary, Alberta, Canada*. Ottawa: National Museum of Man, Archaeological Survey of Canada, Mercury Series Paper 114.

Wilson, M.C. and Burns, J.A.
1999 Searching for the Earliest Canadians: Wide Corridors, Narrow Doorways, Small Windows. *In Ice Age Peoples of North America: Environments, Origins, and Adaptations*, R. Bonnichsen and K. L. Turnmire (editors). Oregon State University Press for the Center for the Study of the First Americans. Corvallis, Oregon. Pp. 213-249.

Wright, C.
1980 A Comparative Analysis of Debitage from a Late Archaic Settlement and Workshop in Northwestern Missouri. In *Archaic Prehistory on the Prairie-Plains Border*, edited by Alfred E. Johnson. University of Kansas, Publications in Anthropology, 12. Lawrence, Kansas. Pp. 43-54.

Zoltai, S.G.
1975 *Southern limit of coniferous trees on the Canadian prairies* Northern Forest Research Centre (Canada), Information Report no. NOR-X-128.Canadian Department of Environment. Canadian Forestry Survey, Ottawa.

Zurburg, S.Z.
1991 The Norby Site: A Mummy Cave Complex Bison Kill on the Northern Plains. Unpublished M.A. Thesis, Department of Anthropology and Archaeology, University of Saskatchewan.

APPENDICES

Appendix 1. Flood Years of the North and South Saskatchewan Rivers

Table A1.1 Peak flooding of the Saskatchewan Rivers in m^3/second

South Saskatchewan		(from Collier 1955)
Flood Year	High flow in m^3/second	Recording Location
1902	5664	Medicine Hat
1953	4163	Saskatoon
Annual Flood	1303	Saskatoon
North Saskatchewan		(from Mustapha et al. 1981)
Flood Year	High flow in m^3/second	Recording Location
1899	4530	Prince Albert
1974	4640	Edmonton

Appendix 2. Faunal Species of the Forks Area.

Table A.2.1. Fur bearers.

Species	Common Name	Boreal	Parkland	In Site	Reference
Castor Canadensis	Beaver	Abundant	Abundant	Yes	Runge and Mulhern 1985
Ondatra zibethicus	Muskrat	Common	Common	Yes	Runge and Mulhern 1985
Tamcasciurus hudsonicus	Red Squirrel	Abundant	Rare	No	Runge and Mulhern 1985
Procyon lotor	Raccoon	Rare	Common	No	Runge and Mulhern 1985
Ursus americanus	Black Bear	Common	Rare	No	Arsenault 2003
Canis latrans	Coyote	Abundant	Abundant	canid sp.	Runge and Mulhern 1985
Canis lupus	Wolf	Rare	None	canid sp.	Runge and Mulhern 1985
Vulpes vulpes	Red Fox	Common	Abundant	No	Runge and Mulhern 1985
Vulpes velox	Swift Fox	None	None	No	Runge and Mulhern 1985
Alopex lapopus	Artic Fox	None	None	No	Runge and Mulhern 1985
Mustela ecminea	Short Tailed Weasel	Common	Common	No	Runge and Mulhern 1985
Mustela frenata	Long Tailed Weasel	Abundant	Common	No	Runge 1993
Mustela vison	Mink	Abundant	Common	No	Runge and Mulhern 1985

Species	Common Name	Boreal	Parkland	In Site	Reference
Martes ameriana	Marten	Rare	None	No	Runge and Mulhern 1985
Martes pennante	Fisher	Common	Abundant	No	Runge and Mulhern 1985
Lutra canadensis	Otter	Common	Rare	No	Runge and Mulhern 1985
Mephitis mephitis	Skunk	Common	Abundant	No	Runge and Mulhern 1985
Gulo gulo	Wolverine	None	None	No	Runge and Mulhern 1985
Taxidea taxus	Badger	Common	Common	No	Runge and Mulhern 1985
Felis canadensis	Lynx	Common	Rare	No	Runge and Mulhern 1985
Felis rufus	Bobcat	None	None	No	Runge and Mulhern 1985

Table A.2.2. Large mammals

Species	Common Name	Boreal	Parkland	In Site	Reference
Bison bison	Bison	Rare	Common	Yes	Bird 1961:9; Meyer and Epp 1990:326
Cervus elaphus	Elk	Common	Common	Yes	Arsenault 1998,2003
Alces alces	Moose	Abundant	Rare	Maybe	Arsenault 2000,2003
Rangifer rangifer	Woodland Caribou	Rare	Absent	Yes	Arsenault 2003
Odecoileus virginianus	White-tailed Deer*	Common	Common	Maybe	Arsenault 2003
Odecoileus hemionus	Mule Deer	Absent	Rare	Maybe	Arsenault 2003

*Historically white-tailed deer were rare in the region (Richardson 1829:253-261).

Table A.2.3. Important rodents and insectivores of the Forks region.

Species	Common Name	Boreal	Parkland	In Site	Reference
Peromyscus maniculatus	Deer mouse	Abundant	Common	?	Pipe 1982
Clethrionomys gapperi)	Red-backed vole	Common	Common	?	Pipe 1982
Microtus pennsylcanicus	Meadow vole	Common	Common	?	Pipe 1982
Sorex cinereus	Masked shrew	Rare	Common	?	Pipe 1982
Sorex arcticus	Arctic shrew	Rare	None	?	Pipe 1982
Blarina brevicauda	Short-tailed shrew	Rare	Common	?	Pipe 1982
Thomomys talpoides	Northern pocket gopher	Present	Present	?	Pipe 1982
Spermophilus richardsonii	Richardson ground squirrel	Present	Present	Likely	Pipe 1982
Spermophilus tridecemlineatus	Thirteen-lined ground squirrel	Present	Present	Likely	Pipe 1982
Tamiasciurus hudsonicus	Red squirrel	Present	Present	?	Pipe 1982

Table A.2.4. Fish of the Saskatchewan River.

Common Name	Nomecature	Reference
Lake Sturgeon	*Acrepenser fulvescens*	Smith 2003; Miles and Sawchyn 1988b
Lake Whitefish	*Coregonus clupeaformis*	Reed 1962; Miles and Sawchyn 1988b
Northern Pike	*Esox lucius*	Reed 1962; Miles and Sawchyn 1988b
Goldeye	*Amphiodon alosoides*	Reed 1962; Miles and Sawchyn 1988b
Mooneye	*Hiodon tergisus*	Reed 1962; Miles and Sawchyn 1988b
Quillback Sucker	*Carpiodes cyprinus*	Reed 1962; Miles and Sawchyn 1988b
Northern Redhorse	*Moxostoma aureolum*	Reed 1962; Miles and Sawchyn 1988b
White Common Sucker	*Catostomus commersoni*	Reed 1962; Miles and Sawchyn 1988b
Longnose Sucker	*Catostomus calostomus*	Reed 1962; Miles and Sawchyn 1988b
Flathead Chub	*Platygobio gracilis*	Reed 1962; Miles and Sawchyn 1988b
Burbot	*Lota lota*	Reed 1962; Miles and Sawchyn 1988b
Walleye	*Stizostedion vitreum*	Reed 1962; Miles and Sawchyn 1988b
Sauger	*Slizostedion canadense*	Reed 1962; Miles and Sawchyn 1988b
Longnose Dace	*Rhunichthys cataractae*	Reed 1962; Miles and Sawchyn 1988b
Emeral Sucker	*Notropsis atheunoides*	Reed 1962; Miles and Sawchyn 1988b
River Shiner	*Notropsis blennius*	Reed 1962; Miles and Sawchyn 1988b
Troutperch	*Percopsis omiscomaycus*	Reed 1962; Miles and Sawchyn 1988b
Yellow Perch	*Perca flavescens*	Reed 1962; Miles and Sawchyn 1988b
Spoonhead Muddler	*Cottus ricei*	Reed 1962; Miles and Sawchyn 1988b
Channel Catfish	*Ictaluus punctalus*	Atton and Merkowsky 1983.

Appendix 3: Radiocarbon Ages of the Culture History.

Table A.3.1. Culture history radiocarbon ages.

Culture Group	Radiocarbon Age Range	Reference
Agate Basin complex	10500 - 10000 rcybp.	Wilson and Burns 1999
Cody complex	9200 - 8800 rcybp.	Wilson and Burns 1999
Terminal Paleoindian series	8800 - 7500 rcybp.	Wilson and Burns 1999
Large Corner-notched tradition	circa 7500 rcybp.	Novecosky 2002
Mummy Cave Series	7500 - 5000 rcybp.	Novecosky 2002
Early Oxbow complex	5900 - 4700 rcybp.	Morlan 2003; personal observation.
Oxbow complex	4700 - 4000 rcybp.	Novecosky 2002
McKean complex	4440 - 3295 rcybp.	Novecosky 2002
Pelican Lake complex	3825 - 2895 rcybp.	Novecosky 2002
Pelican Lake complex -late	2385 - 2285 rcybp.	Novecosky 2002
Besant complex	2675 - 1390 rcybp.	Novecosky 2002
Avonlea complex	1950 - 920 rcybp.	Meyer and Epp 1990; Novecosky 2002
Laurel composite	2000 - 900 rcybp.	Morlan 2003; personal observation.
Laurel composite in Saskatchewan	1200 - 700 rcybp.	Morlan 2003; personal observation.
Late Side-notched series	1500 - 0 rcybp.	Morlan 2003; personal observation.
Selkirk Composite	800 - 150 rcybp.	Morlan 2003; personal observation.

Appendix 4: Radiocarbon Dates of the Mummy Cave Series.

Table A.4.1.Radiocarbon dates of the Mummy Cave series.

False Cougar Cave	S-5651	8255 .+/- 120	Bonnichesen et al. 1986, Bonnichesen and Bowlen 1985
Boss Hill	S-1251	7955 .+/- 130	Doll 1982
Boss Hill	S-1371	7750 .+/- 105	Doll 1982
Itasca	M-1726	7740 .+/- 250	Walker 1992
False Cougar Cave	SI-5288	7655 .+/- 170	Bonnichesen et al. 1986, Bonnichesen and Bowlen 1985
Fletcher	S-1084	7655 .+/- 110	Morlan 2003
Mummy Cave	I-1588	7630 .+/- 170	Frison 1991
Rustad Quarry	Beta-85217	7590 .+/- 90	Michlovic 1996
Rustad Quarry	Beta-70150	7550 .+/- 90	Michlovic 1996
False Cougar Cave	S1-5290	7385 .+/- 105	Bonnichesen et al. 1986, Bonnichesen and Bowlen 1985

Itasca	M-1730	7370 .+/- 250	Shay 1971; Walker 1992
Hawkwood	RL-1276	7275 .+/- 215	Brumley and Rushworth 1983
Stampede	S-731	7245 .+/- 255	Gryba 1975
Rustad Quarry	Beta-58200	7240 .+/- 150	Michlovic 1996
Looking Bill	RL-554	7220 .+/- 160	Frison 1991
False Cougar Cave	SI-5652	7185 .+/- 110	Bonnichesen et al. 1986, Bonnichesen and Bowlen 1985
Rustad Quarry	Beta-70149	7180 .+/- 90	Michlovic 1996
Mummy Cave	I-1587	7140 .+/- 170	Frison 1991
Indian Creek	RL-1199	7070 .+/- 230	David and Hill 1998
Hawkwood	RL-1277	6900 .+/- 280	Morlan 2003
East Village Access	S-2739	6825 .+/- 95	Kasstan 2003
Mummy Cave	I-2358	6780 .+/- 130	Morlan 2003
Indian Creek	RL-1206	6770 .+/- 180	Morlan 2003
Gap	GSC-1298	6720 .+/- 170	Reeves and Dormaar 1972
East Village Access	S-2737	6635 .+/- 185	Kasstan 2003
Mountain Creek	Riddl-n/a-2	6620 .+/- 120	Head 1987, Porter 1988, Wilson 1987;
East Village Access	S-2738	6480 .+/- 100	Kasstan 2003
Whitemouth Falls	Gak-6494	6450 .+/- 110	Buchner 1979; Ens 1998
Maple Leaf	RL-508	6420 .+/- 160	Driver 1985,1986
Gowen 1	S-1457	6230 .+/- 110	Walker 1992
Whitemouth Falls	Gak-6493	6170 .+/- 110	Buchner 1979, Ens 1998
Gowen 2	S-1971	6160 .+/- 160	Walker 1992
Gowen 1	S-1488	6150 .+/- 260	Walker 1992
Indian Creek	RL-1201	6150 .+/- 390	Morlan 2003
Boss Hill	S-1250	6150 .+/- 95	Doll 1982
Below Forks	TO-9354	6100 .+/- 140	Meyer 2000
Whitemouth Falls	NSRL-3128?	6090 .+/- 90	Buchner 1979; Buchner and Pujo 1977; Ens 1998
Gap	GSC-1255	6060 .+/- 140	Morlan 1982
Below Forks	TO-9355	6010 .+/- 80	Meyer 2001
Gowen 2	S-1970	6000 .+/- 130	Walker 1992
Gowen 2	S-2036B	5990 .+/- 170	Walker 1992
Norby	S-3006	5965 .+/- 265	Zurburg 1991
Sun River	Beta-5533	5960 .+/- 210	Greiser et al 1985
Below Forks	S-2245	5925 .+/- 140	Morlan 2003
Welsh	ASA-D90-059	5920 .+/- 170	Beaudoin 1991; 1998
Norby	S-3205	5820 .+/- 110	Zurburg 1991
Mummy Cave	I-2350	5800 .+/- 120	Morlan 2003; Husted 2002
Head-Smashed-In	RL-334	5740 .+/- 100	Reeves 1978
Below Forks	S-1994	5740 .+/- 100	Meyer 2000
East Village Access	S-2740	5740 .+/- 90	Kasstan 2003
Bill White	n/a-38	5730 .+/- 180	Brumley and Rushworth 1983, Reeves 1980; Wilson 1983.

Playa III	Beta-12418	5720 .+/- 100	Newton 1985; Morlan 2003
Mona Lisa	GX-6395 A	5715 .+/- 150	Brumley and Rushworth 1983
Gowen 2	S-2037	5670 .+/- 110	Walker 1992
Norby	S-3206	5640 .+/- 120	Zurburg 1991
Mummy Cave	I-1585	5610 .+/- 280	Morlan 2003
Myers-Hindman	Gak-2632	5590 .+/- 150	Morlan 2003
DjPq-1	GX-6388	5575 .+/- 185	Morlan 2003
DjLg-10a	TO-7052	5550 .+/- 70	Morlan et al. 2000
Anderson	GX-6130	5540 .+/- 160	Morlan 2003
Head-Smashed-In	GSC-803	5490 .+/- 300	Reeves1978
Sorenson	I-692	5475 .+/- 190	Husted 1969, Walker 1992
Barton Gultch	RL-1378	5420 .+/- 170	Aaberg et al. 1996; Davis and Hill 1995; Davis et al. 1988,1989, 1995.
Mummy Cave	I-1466	5390 .+/- 140	Morlan 2003
Mona Lisa	GX-6394 A	5390 .+/- 170	Brumley and Rushworth 1983
Barton Gultch	RL-1151	5330 .+/- 170	Aaberg et al. 1996; Davis and Hill 1995; Davis et al. 1988,1989, 1995.
DjPq-1	RL-1662	5270 .+/- 150	Morlan 2003
DjPq-1	RL-1663	5270 .+/- 150	Morlan 2003
Mummy Cave	I-1429	5255 .+/- 140	Morlan 2003; Husted 2002
Gowen 1	S-2036 A	5160 .+/- 150	Walker 1992
Head-Smashed-In	RL-333	5160 .+/- 120	Reeves1978
Gowen 1	S-1526	4810 .+/- 130	Walker 1992
Anderson	GX-6129 G	4805 .+/- 150	Quigg 1984
DgPo-9	RL-507	4770 .+/- 130	Morlan 2003
Stone Pipe	Beta-127234	4690 .+/- 70	Morlan 2003
Myers-Hindman	GX-1490	4680 .+/- 220	Lahren 1976
Jarrett	W-2885	4630 .+/- 250	Morlan 2003
Boy Chief	AECV-2029	4500 .+/- 70	Morlan 2003
Boy Chief	AECV-2027	4420 .+/- 90	Morlan 2003
Farrel Creek	WSU-1953	4365 .+/- 100	Morlan 2003
Boy Chief	AECV-2025C	4360 .+/- 80	Morlan 2003
Boy Chief	Beta-43912	4350 .+/- 90	Morlan 2003
Corwin Springs	RL-1368	4300 .+/- 160	Morlan 2003
DjPn-16	AECV-218C	4160 .+/- 230	Morlan 2003
Head-Smashed-In	GaLC-1476	4130 .+/- 100	Reeves 1978
DjPn-16	AECV-216C	4040 .+/- 140	Morlan 2003
Crowsnest Dance Hall	RL-367	3920 .+/- 130	Reeves 1974a,1974b
Crowsnest Dance Hall	RL-366	3910 .+/- 140	Reeves 1974a,1974b
DgPl-1	GX-1460	3890 .+/- 215	Reeves 1972
Head-Smashed-In	GX-6387	3870 .+/- 190	Reeves 1978
Crowsnest Dance Hall	RL-363	3860 .+/- 140	Reeves 1974a,1974b

Dates Below Are	Excluded		
Charlie Lake Cave	SFU-451	4800 .+/- 640	Morlan 2003
Charlie Lake Cave	SFU-385	4400 .+/- 400	Morlan 2003
Pretty Creek	Ugs-957	7685 .+/- 580	Walker 1992
False Cougar Cave	Beta-5753	7560 .+/- 500	Bonnichesen et al. 1986, Bonnichesen and Bowlen 1985
Swan Landing	S-2179	7010 .+/- 1560	Beaudoin 1987
DjPn-13	GX-6383	5685 .+/- 550	Brumley and Rushworth 1983
DjPq-1	GX-6387	3510 .+/- 185	Morlan 2003
DjPo-9	RL-773	3200 .+/- 130	Morlan 2003
Jensen Springs	AECV-112	6040 .+/- 450	Walker 1992
Farrell Creek		5830 .+/- 80	Valentine et al. 1980; Pickard 1987

Appendix 5: Methods to Create 3D Representation of Objects Without a 3D Scanner.

Step 1): *Take a digital photograph of the object*. The photo must include a reference grid surrounding the object. The camera lens must be level. A bubble level on the camera is a good method to level the lens. Lighting is of great importance, the lighting should be set up to show the best relief of the object.

Step 2): *Import the digital photograph into a computer as a Bitmap (*.bmp*). The image should be cropped to the reference grid. I sometimes have to rotate the image a few degrees to create a straight grid. If the reference grid on the image is not rectangular (i.e. the camera was not level) then a new photo should be taken. There is always a bit of error with the grid cropping, and the "acceptable" error is somewhat subjective. Acceptable error depends on the project.

Step 3): *The cropped image should be geo-referenced*. I use the "image conversion" function in CartaLinx *file* window. Essentially, I am setting the geographical coordinates for the corners of the image. The program asks for maximum and minimum X and Y coordinates and the unit scale (metres, centimetres, kilometres, etc.). For a single object, the scale can be an arbitrary datum point of (0,0 cm), or can be referenced to a UTM datum. If the true space in the world is important, like incorporating objects on a landscape, then UTMs should be used. The easiest way to incorporate UTMs is to take a standard UTM coordinate of object location on a GPS, then to use that UTM data to set the minimum X and Y coordinates for geo-referencing.

To find the maximum X and Y coordinates simply add the grid size to the minimum UTMs.

Step 4): *Open the geo-referenced image in a spatial digitizing program* (I use CartaLinx). Didger is another program commonly used. For Cartalinx, the function I use is New Coverage, Coverage based on Bitmap in the *file* window. Set the snap and other tolerances for digitizing, and add data fields to Nodes and to Arcs, set the field as: value, double precision real. The created field is where the elevation (Z dimension information is created).

Step 5): *Digitize (create) contours for the object*, placing them on top of the image. I tend to start from the outside and work my way to the centre. Also confirm the value fields for each topographic line or node.

Step 6): *Export the contours/points into a GIS format*. I tend to export my 3D information as ArcView shapefiles, and export arcs as lines. One can also export nodes as points. If the object was digitized using both contour lines and key point landmarks, then one needs to export both data sets (arcs, points) separately. At this point I tend to keep Cartalinx on, and then open ArcView. This is handy, since I often need to correct mistakes in the "source data". Common errors are incorrect elevation values and locales where the GIS have interpreted outside/between contour lines (especially problematic in TIN environments).

Step 7): *Open the shapefiles in the GIS*. I tend to setup a new project in ArcView 3.2, setting up a default save directory, and add the spatial analysis and 3D analyst extensions. In ArcView 8.0, the spatial analyst and 3D analyst are activated in to tools window. I sometimes add GIS extensions to solve specific problems (especially the TIN to Shapefile function). Anyways, open the new project and import the shapefiles using the Add Theme function on the View, Theme window.

Step 8): *Create TIN based on shapefile*. I use the "create TIN" button, and always have to set the elevation value field. If the object has points and lines, simply select both themes before hitting the TIN button. One then has to set elevations for both data sets. In the View I tend to get a fair idea of how the object will look, and the nature of mistakes (especially elevation value mistakes).

Step 9): *Open the TIN in a 3D view* to get a sense if the shape is correct. If there are mistakes I go back to CartaLinx and repair the data. No TIN is ever completely perfect, and there is always a point where I think that I have come as close as I can to a correct representation of the object.

Step 10): *Export the 3D view as a JPG, BMP or VRML 2.0*. All are useful formats for papers, presentations and the net. I always export the 3D view with the greatest number of pixels and resolution possible. At this stage I always lose about an order of magnitude of resolution in image quality. ArcView 8.0 can create a 3D animation and save it as an AVI (a operation video format for power point presentations).

Step 11): In a graphics program, create titles and tweak the colour, brightness/contrast (Adobe, Corel Photoshop, and etc..). For some unknown reason, ArcView 3.2 images are always too dark and the contrast is rather uniform. I usually increase the contrast, increase the brightness, and sometimes sharpen the image. ArcView 8.0 has a brightness/contrast function incorporated into the program.

Appendix 6. Lithic Analysis Hardcopy Worksheet.

Below Forks (FhNg-25) Lithic Analysis Sheet

Steve Kasstan

Date:

Cat#

Unit #:

Provience: N E BD Plan #:

Level: Quad Bag: NW NE SE SW

Debitage Type
Flake Shatter Rejuv Other
Core Core Frag Fcr

Material Type:

Colour:

Thermal Alteration: Present Absent

Mass: ___________ grams.

Exterior Cortex: 0 1-25 26-50 51-75 76-99 100

Bulb of Percussion: Present Absent
Pronounced Weak

Dorsal Scar Morphology:
Plain Cortical with Retouch

Number of Scars:_______

mm. Max Length
mm. Max Width
mm. Max Thickness
mm. Platform Thickness
mm. Thickness at Bulb or 1/4
mm. Thickness at Middle
mm. Thickness at 3/4
mm. Platform Width
mm. Width at 1/4
mm. Width at Middle
mm. Width at 3/4

* broken

split

n/a >

Termination:
Feather Hinge Step Outrepasse Crushed

Longitudinal:
Complete Incomplete
Proximal Medial Distal

Latitudinal:
Complete Incomplete
lt. split lt. broken rt. split rt. broken

n/a >

Platform: Present Absent

Modification:
Plain Flaked Ground Crushed

Lip: Present Absent

Cortex: 0 1-25 26-50 51-75 76-99 100

Shape:
Rectangular Triangular Oval Diamond
Cresent Discoidal Other Indeterminate

< n/a

Platform Flake Scars: 1 2 3 _____

Detachment Technique:
Hard Soft Press Indet

<

Notes

Flake Type:
Bipolar Shaping Bifacal Redu Thinning
Decort Other Indet N/A

Appendix 7: Definitions of Lithic Material Types.

Agate: "Agate - a translucent variety of chalcedony, characterized by alternating bands of color indicating successive periods of deposition. (Finnegan, et al. 1985:9-3 citing Hamblin and Howard 1975:113)."

Basalt - "a fine grained, dense black to olive green rock with a smooth to rough texture. Being igneous in nature, basalt is typically opaque (see Loy and Powell, 1977)". (Finnegan et al. 1985:9-3).

Chalcedony - "a compact siliceous rock composed of quartz. It lacks graininess and is predominately translucent" (Finnegan et al. 1985:9-3). "Chalcedony: a fine grained quartz with a conspicuous fibrous microstructure visible in thin section (Frondel 1962:195-223)".

Chert- " a compact, siliceous rock formed of silica or a precipitates origin formed of quartz particles. Most varieties of chert are opaque"(Finnegan et al. 1985:9-3). "Chert: a rock composed of microcrystalline quartz. It occurs in a wide variety of forms and colors, being found ion limestones, dolomites, and argillites. It also occurs as pockets and interbeds with pillow lava and tuffs" (Moorhouse 1959:383).

Gneiss: "granitic rock showing banding or directional texture resulting from orientation of grains or aggregates of mineral grains" (Pearce and Gullov 1996:56).

Granite: "Granite' as a dimension stone granite broadly describes crystalline plutonic and some metamorphic rocks with a granite texture. Colour and textural or structural terms may also be used as part of the commercial description of granite" (Pearce and Gullov 1996:56).

Gronlid siltstone: Meyer and Carter (1978) identified an exposure of shale containing Gronlid siltstone by the Saskatchewan River in the Gronlid Ferry area.

Gronlid siltstone was formerly known as River House chert. Finnegan et at. (1985:9-5 - 9-6) define the material as:

> a chert found in regional shale beds which occurs as flat nodules with heavily patinated, white cortexes. This material has a glassy texture and is opaque. The color may vary slightly, with black being the predominant. Lighter gray flecks are present, sometimes only visible microscopically.

Limestone: "A sedimentary rock consisting chiefly of the mineral calcire (calcium carbonate $CaCo^3$), with or without magnesium carbonate. Common impurities include chert and clay." (Bates and Jackson 1984:295).

Quartz:

> quartz - one of the most common of all minerals, a crystalline silica. Although the color-range may vary widely, the most common quartz varieties are clear or milky translucent (see Loy and Pywell 1977)[sic]. Individual crystals are usually visible and cleavage is poor. (Finnegan et al. 1985:9-5)

Quartz often shatters since it does not conchoidal fracture.

Quartzite: A definition outlining the formation process of quartzite is presented in Bates and Jackson (1984:415)

> 1) A granoblastic metamorphic rock consisting mainly of quartz, formed by the recrystallization of sandstone by regional or thermal metamorphism; a metaquartzite, 2. A sandstone consisting of quartz grains cemented by secondary silica; an orthoquartzite.

Red River chert: is a limestone chert of the Cathead Member (Baille 1952), and is also known as Cathead chert. "It occurs in a variety of mottled colours, white, cream, tan, red and gray white banded. It is a very hard material with a good conchoidal fracture "(Leonoff 1970:14). Leonoff (1970:25-26) continues:

> Cathead Member of the Red River formation of dolostone of Ordovician Age (Baille 1952)[sic], from the west point of Lake Winnipeg. The bedrock source is 43 feet in thickness with 3 units. Chert nodules in Dolostone, laminations are sometimes continuous through the chert nodules but may be curved around it. (the laminations from Dolostone bedding plains.

"Cathead [Red River] chert - a variety of chert which exhibits a dull to semi-vitreous luster and conchoidal fracture with good flaking qualities. An opaque material, its distinguishing characteristic is its alternating bands of various shades of gray " (Finnegan et al. 1985:9-3). The banding is actually white and gray. The argument for the Red River Chert name is that it indicates which geological formation the raw material is coming from. Problematic to the issue, is that the Red River formation is composed of many different types of rock, and chert is present in limited quantities. I prefer the term Cathead chert, but I herein use the Red River chert name to avoid confusion.

Red Willow Creek silicified sandstone: Finnegan et al (1985) define this material as:

> Red Willow Creek sandstone is a variety of silicified sandstone identified in the Carrot River valley by David Meyer. It is characterized by a glassy lustre and yields a semi-conchoidal fracture in which the break is across the grains. The colour is gray with black speckles of a foreign material. An unconsolidated brown sandstone cortex sometimes adheres to cores of this material.

Red Willow Creek silicified sandstone was knapped as is, without thermal alteration, and tended to shatter.

Schist: "a large group of coarse grained metamorphic rocks which readily split into thin plates or slabs as a result of the alignment of lamellar or prismatic minerals [mica/hornblende - SK] (Parker 1997:338).

Silicified wood : formerly known as petrified wood, "results from the replacement of wood by cryptocrystalline quartz during the fossilization process. The original structure of the wood is retained" (Finnegan et al. 1985, citing (Hamblin and Howard 1975:13)).

Swan River chert: Leonoff (1970:12-13) provided the first definition of Swan River chert. Swan River chert:

> has regular conchoidal fracture, considerable variation from coarse crystalline to cryptocrystalline (within on piece). In thin section the composition of Swan river chert was found to be quartz with chalcedony as a cementing medium. Large radial crystals are visible with fine chalcedony fillings, colour - white to gray, pink and deep rust, (jasperoid), pale yellow to deep orange. Lustre - glossy to waxy to dull in appearance.

The term 'Swan River chert' appeared over the course of the Glacial Lake Agassiz archaeological survey in Northern Manitoba (Leonoff 1970:1;28-29). Simply, survey crew members associated the concentrated areas of this material in the Swan River area of Manitoba (Leonoff 1970:29). Swan River chert has droosy vugs with voids, quartz crystals, and irregularities (Johnson 1986; Low 1996). SRC has a complex microscopic texture of cryptocrystalline quartz (Grasby et al. 2002). The granoblastic quartz often formed in radial aggregates with pore filling, cryptocrystalline quartz formed spherical aggregates and filled small vugs, while massive cryptocrystalline quartz formed the matrix (Grasby et al. 2002). A bedrock source was located in the Dawson's Bay area of Lake Winnipegosis, in Devonian, and to some degree Silurian fossiliferous limestone and dolomites (Grasby et al. 2002:275-283,Low 1996). Swan River chert formed in solution chimneys, a brine soup that replaced the calcium carbonate of the stone with silica (Grasby et al. 2002). Over the past glaciation, solution chimneys in the greater Lake Winnipegosis region were removed and redeposited in the glacial tills throughout central Saskatchewan and western Manitoba (Grasby et. Al. 2002). The solution chimneys were inaccessible to people for quarrying (Grasby et al 2002), instead SRC was procured from exposed glacial tills (Leonoff 1970; Low 1996).

Appendix 8. Definitions of Termination Types.

Step Termination: "a form of the distal end of a flake where it ended abruptly in a right angle break" (Kooyman 2000:177), see also (Pelcin 1997a, 1997b).

Feather Termination: "a form of the distal end of a flake where the end gradually thinned to a very sharp edge" (Kooyman 2000:172), see also (Pelcin 1997a,1997b).

Hinge Termination: "a form of the distal end of a flake where the fracture rolled out to the dorsal surface, and produced a rounded or curved distal end" (Kooyman 2000:173), see also (Pelcin 1997a,1997b; Sollberger 1994).

Outrepassé Termination: "a form of the distal end of a flake where the fracture removed the end or edge of the lithic piece being worked and so this end or edge became the termination of the flake, the resultanlt termination was generally *hooked* " (Kooyman 2000:175), see also (Pelcin 1997a, 1997b).

Crushed Termination: a form of the distal end of a flake that has been damaged or shattered on a anvil during bipolar production. Appears quite similar to crushing on platforms (Low 1996:61-62).

Appendix 9. Definitions of Flake Completition.

The following definitions are based on personal obervations of the Below Forks assemblage. Appreciably, I acknowledge Andrefsky (1998) as a guiding influence for the observations.

Proximal flake - was a flake orientable proximal/distal that had a platform and terminated with a step fracture.

Medial flake - was a flake orientable proximal/distal that lacked a platform and an obvious hinge, feather, outrepasse or crushed termination. Medial flakes often has a portion of a bulb of percussion which allowed for proximal/distal orientation.

Distal flake - was a flake orientable proximal/distal that lacked a platform but had an obvious hinge, feather, outrepasse or crushed termination.

Non-orientable flake - was a flake unorientable proximal/distal. These flakes lack a platform and obvious hinge, feather, outrepasse or crushed termination.

Split flake - was a flake where the platform has been longitudinally broken by a step fracture.

Longitudinally broken flake - was a flake orientable proximal/distal, that had a longitudinal break along the lateral flake margins. Longitudinally broken flakes either had a complete platform, or were without a platform. These flakes either had complete lengths, were medial flake fragments or distal flake fragments.

Appendix 10. Platform Shapes.

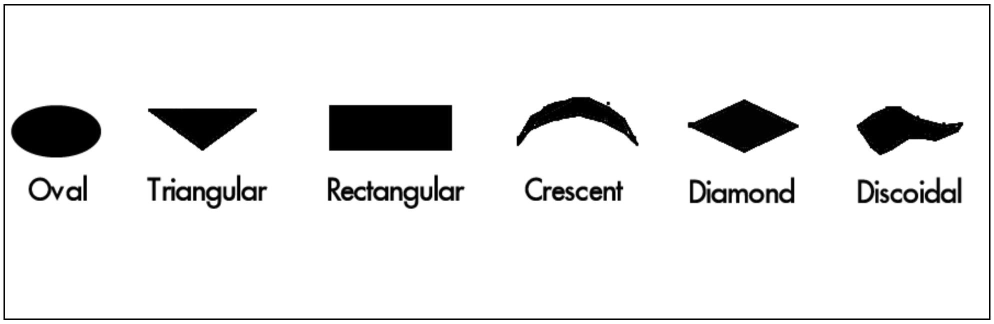


Figure A.10.1 Platform shapes

Appendix 11. General Definitions for The Lithic Analysis.

A 11.1 Introduction to Lithic Definitions.

The definitions of lithic debris and cores generally follow Kooyman (2000). Important differences in definitions are a result of my personal observations on the Below Forks site assemblage.

A 11.2 Debitage, Flake, Shatter, Core.

Debitage: "the discarded garbage or debris resulting from the manufacture of lithic tool" (Kooyman 2000:171).

Flake: *a piece of lithic material that was orientable dorsal/ventral, showed a definite original surface and a newly created inner surface.* Kooyman (2000:172-173) defined flakes as follows:

> Flake: a piece of lithic material usually intentionally detached from another piece of lithic material (such as a core, tool, etc.), with a series of features showing that it has a definable original surface and a newly created inner surface, as well as a place where the detaching blow was struck (e.g., bulb of percussion, ripple marks, striking platform, arris) (see also shatter).

Kooyman's definition of flakes was too specific for analysis, mainly for its insistence on the presence of a flake platform. This insistence ignores flake breakage.

Complete Flake: a flake that had a platform, a place where the detaching blow was struck, a feather, hinge, outrepasse, or crushed termination, and lacked lateral step fractures.

Shatter: a piece of lithic materal unorientable dorsal/ventral that lack a platform and a bulb of percussion. I consistently identified two types of shatter. The first was *chunk shatter,* which was angular and blocky. The second type was *thin shatter:* these items were flake like items where the two surfaces seemed to equally have been the ventral surface of detachment from raw material. To avoid confusion these two types of shatter were lumped together in the analysis. Kooyman (2000:176) provided a definition that was too vague for use:

> Shatter: a piece of lithic material generally detached inadvertently from another piece of lithic material (core or other piece of material such as a tool) when intentionally trying to detach another piece of lithic material (a flake), produced by the shattering of the piece from which it was struck.

Core: "any piece of lithic material from which another piece of lithic material has been detached for the purpose of a tool, or to manufacture into a tool". (Kooyman, 2000:170).

A.11.3. Platform Modifications.

Plain Platform: No evidence of any change to the platform surface, where the platform presented a homogeneous surface for flake initiation.

Flaked Platform: The platform has been modified by stricking small flakes either across the platform surface, or along the exterior platform edge (Kooyman 2000). These two types were lumped together for the debitage analysis.

Ground Platform: The platform was modified by abrasion of a hard object (Kooyman 2000). Grinding generally had the appearance of "railway tracks", linear striae, either along the surface of the platform or along the exterior platform edge. Grinding was perceptible under magnification and by feel.

Crushed Platform: The platform was modified by concussion of a solid object (i.e. Low 1996:61-62). Often impact point crushing was present as a semi-circular pock mark on the surface, usually located close to the interior edge, and sometimes associated with an eraillure scar. Larger and more extensive crushing occurred on surfaces producing 'micro-shatter' which could destroy and collapse the platform. When this occurred I noted in the catalogue that the platform morphology was indeterminate due to platform crushing.

Platform Lip, An overhang of material of the platform surface over the interior edge, observable by sight, under magnifiaction, and by feel (Crabtree 1972:74-75). Sometimes the platform did not extend across the entire interior platform edge, in these instances if the lip was present on ever one-half of the edge, then a platform lip was present. Alternatively, if the lip was present on under one-half of the edge then a lip was absent. For the feel of the platform lip, I ran my thumbnail along the ventral surface from the termination up to the platform, if a lip was present I could not smoothly pass my thunbnail across the interior platform edge.

A.11.4. Bulbs of Percussion.

Pronounced Bulb: Hertzian fracture that yeilded a large buldge on the vental surface of a flake below the platform (Kooyman 20-22). Following a suggestion by Andrefsky (1998), a metric thickness cutoff seperated between pronounced and weak bulbs. If the thickness of the bulb in relation to the thickness of the platform was greater than 1mm, then the bulb was pronouced.

Weak (Diffuse) Bulb: Conchoidal fracture that yielded a small buldge on the ventral surface of a flake below the platform (Kooyman 20-22). A metric thickness cutoff seperated between pronounced and weak bulbs. If thickness of platform to bulb wass less then 1mm, then the bulb was weak.

Appendix 12. The Thermal Alteration of Debitage

Table A.12.1. Frequency of thermal alteration of SRC by occupation.

Occupation	Heated	Maybe Heated	Not Heated	Total
Upper Occupation	539	19	41	599
Level 3	137	5	17	159
Middle Occupation	507	14	57	578
Level 7	455	17	89	561
Lower occupation	16866	241	3440	20547
Total	18504	296	3644	22444

Table A. 12.2. Weight of thermal alteration of SRC by occupation.

Occupation	Heated	Maybe Heated	Not Heated	Total
Upper Occupation	2169.9	47.2	976.3	3193.4
Level 3	277	20.1	37	334.1
Middle Occupation	956.5	67.6	169.2	1193.3
Level 7	593.9	31.3	110.3	735.5
Lower occupation	8743.6	274.4	1965.4	10983.4
Total	12740.9	440.6	3258.3	16439.7

Appendix 13: Sullivan and Rosen Technique Analysis of the Lower Occupation.
(Following (Sullivan and Rosen 1985; Bradbury and Carr 1995))

Table A.13.1. SRT by frequency

Material	Complete	Broken	Fragment	Debris
SRC	473	1537	938	1238
RRC	4	8	4	6
Red Willow	2	13	7	11
Chalcedony	2	8	3	5
Quartzite	23	39	21	30
Quartz	6	16	5	13
Gronlid Siltstone	3	10	9	3

Table A.13.2. SRT by weight

Material	Complete	Broken	Fragment	Debris
SRC	1106.5	2374.4	1131.8	2223.9
RRC	2.2	7.5	1.5	12.3
Red Willow	1.4	16.2	13.5	35.9
Chalcedony	3.9	2.8	3.3	3
Quartzite	11.5	105.4	26.8	55.1
Quartz	29.4	35.6	6.2	17.2
Gronlid Siltstone	0.4	6.3	8.7	2.7

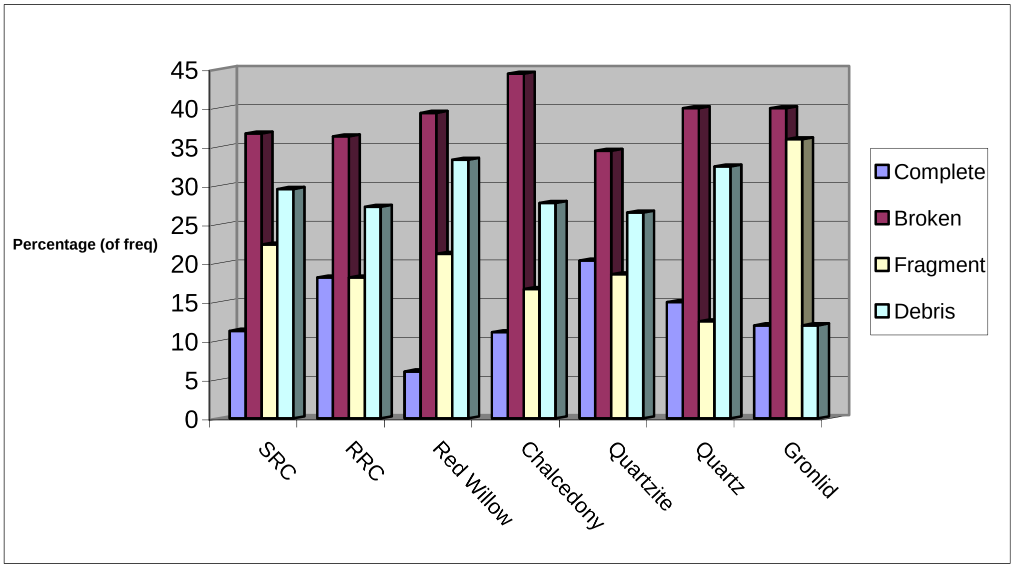


Figure A.13.1. Sullivan and Rosen technique for Below Forks by frequency.

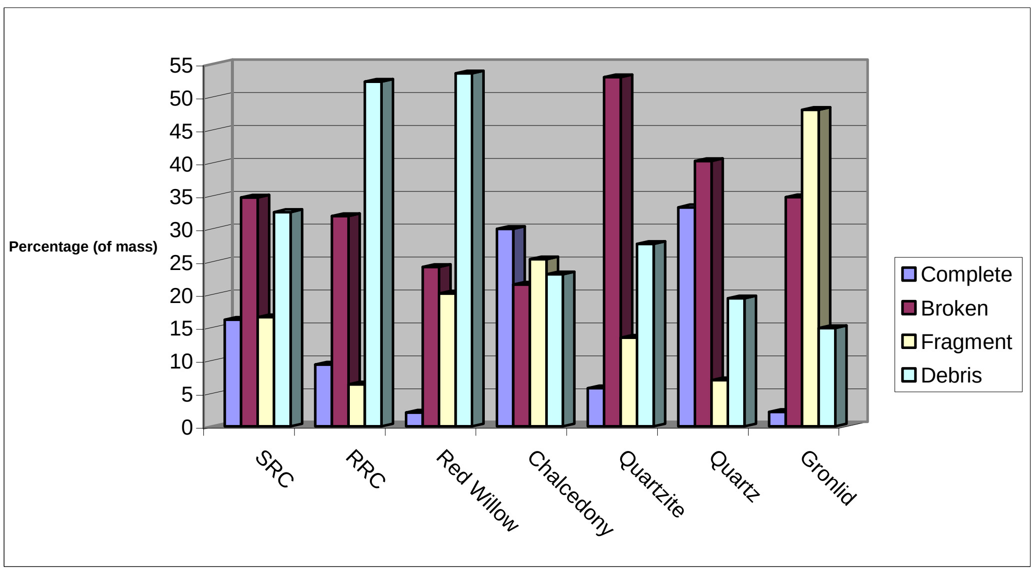


Figure A.13.2. Sullivan and Rosen technique for Below Forks by weight.

Appendix 14: Photography of Debitage.

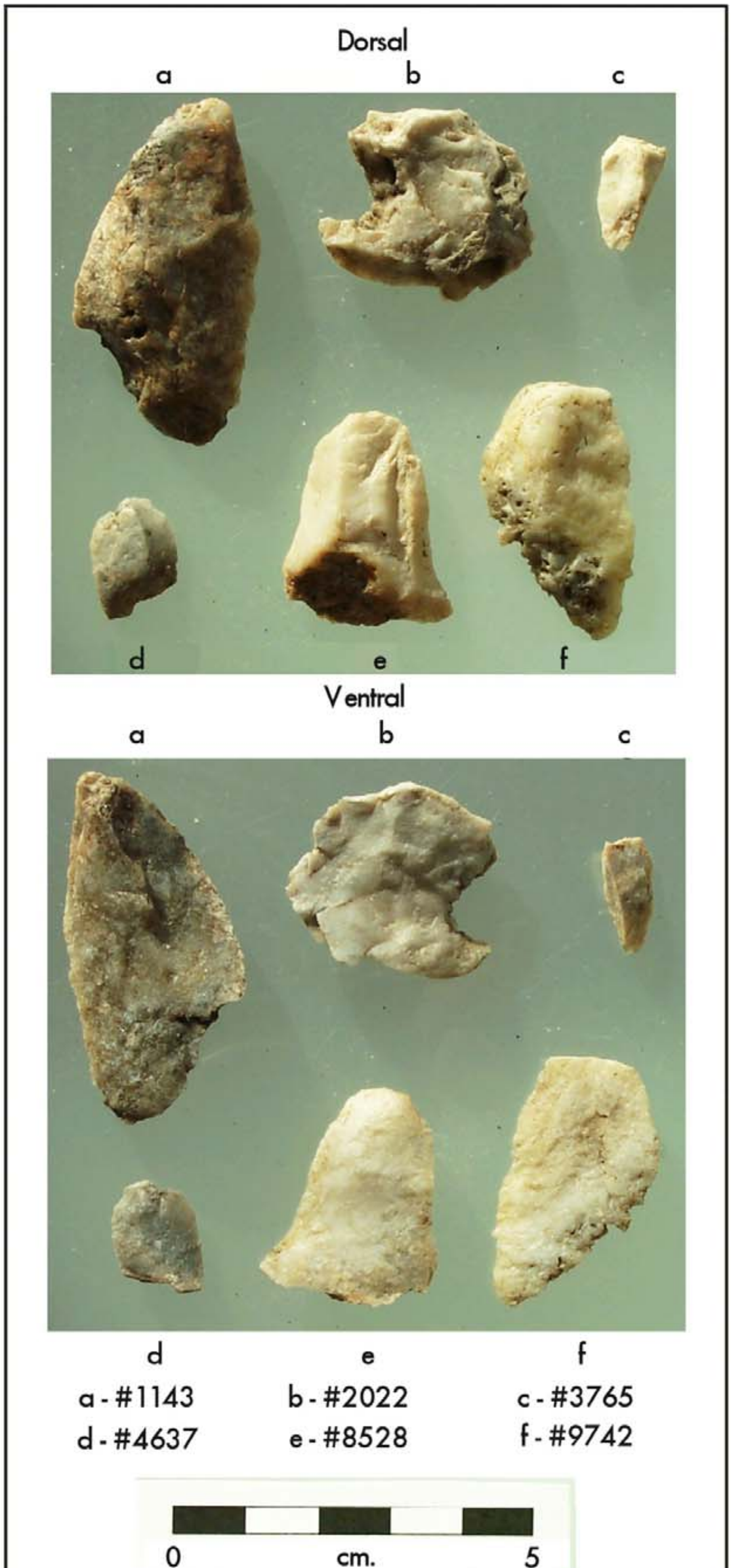


Figure A.14.1 Primary Decortication Flakes

Figure A.14.2 Bipolar Technique Secondary Decortication Flakes.

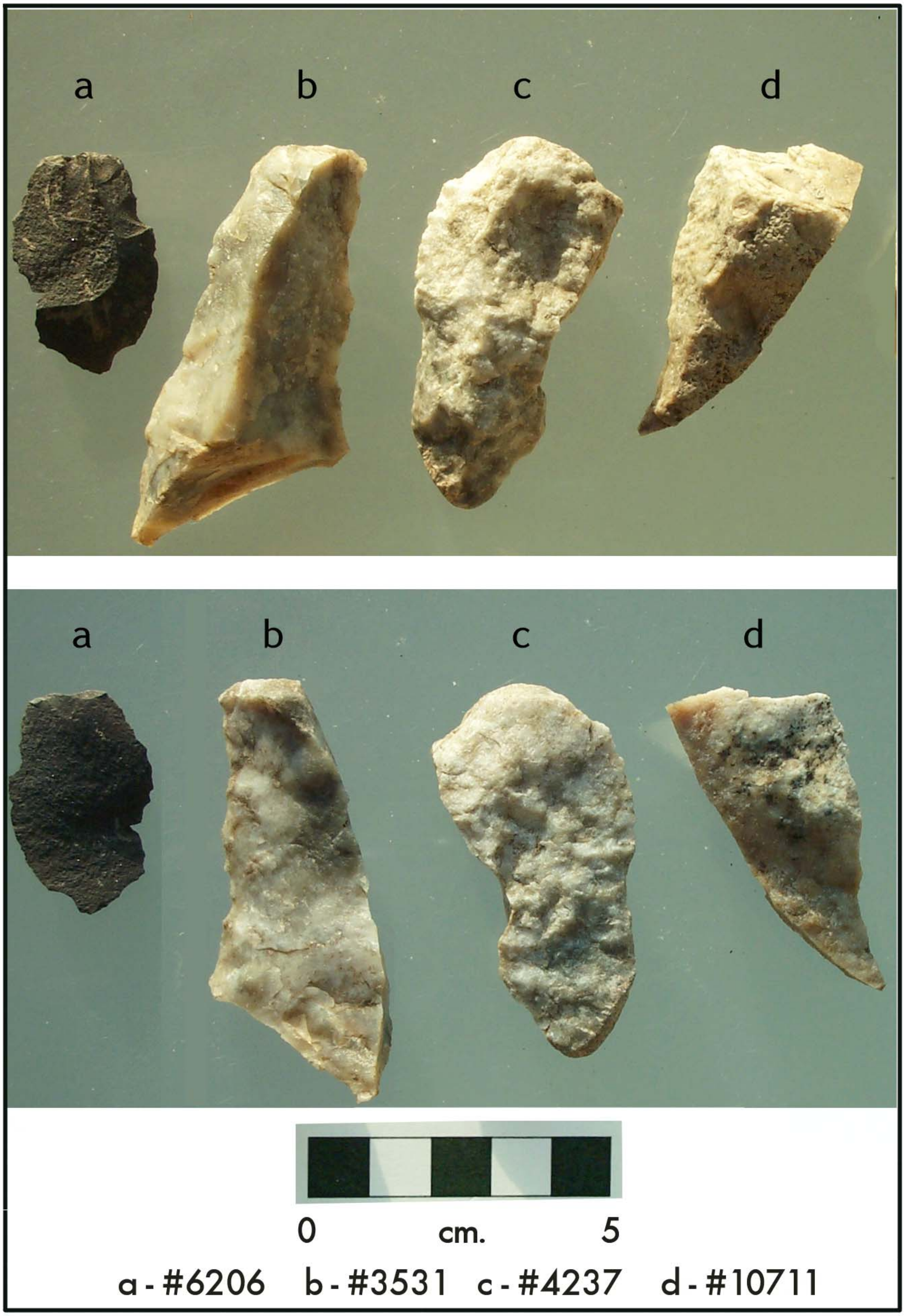


Figure A.14.3. Tertiary decortication flakes.

Figure A.14.4. Bipolar technique secondary decortication flakes.

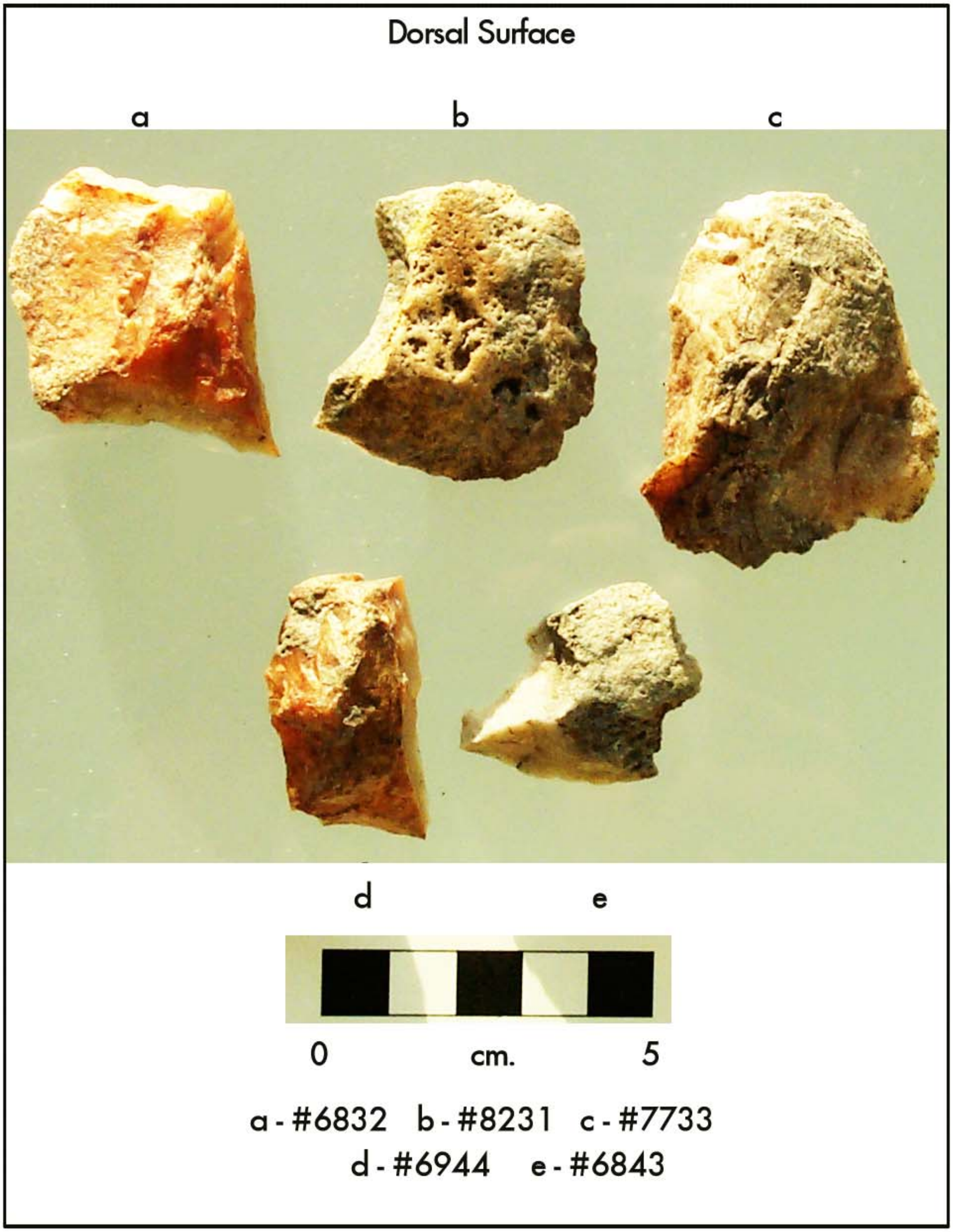


Figure A.15.5. Bipolar technique secondary decortication flakes.

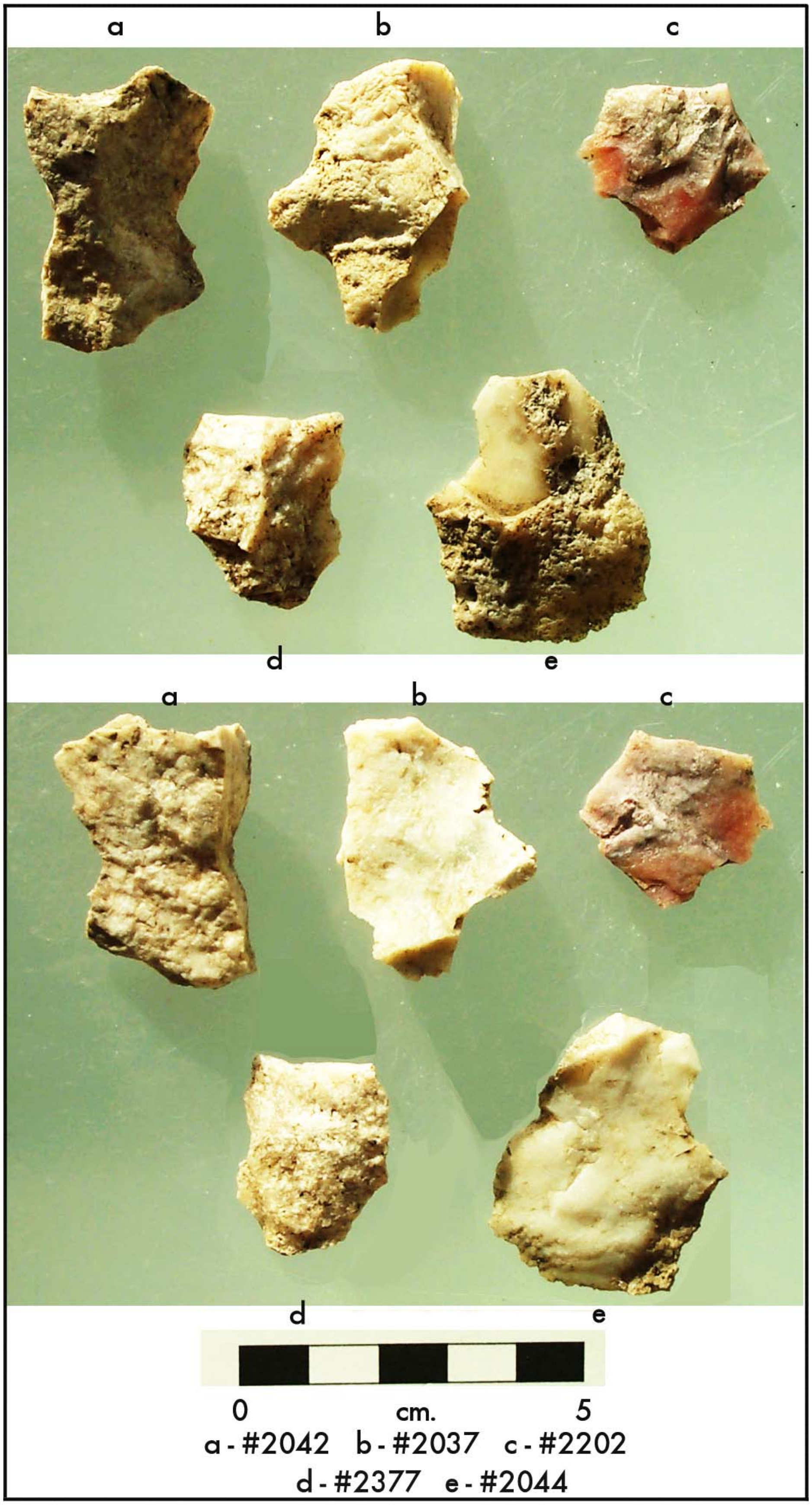


Figure A.14.6. Bipolar flakes, some tertiarty decortication.

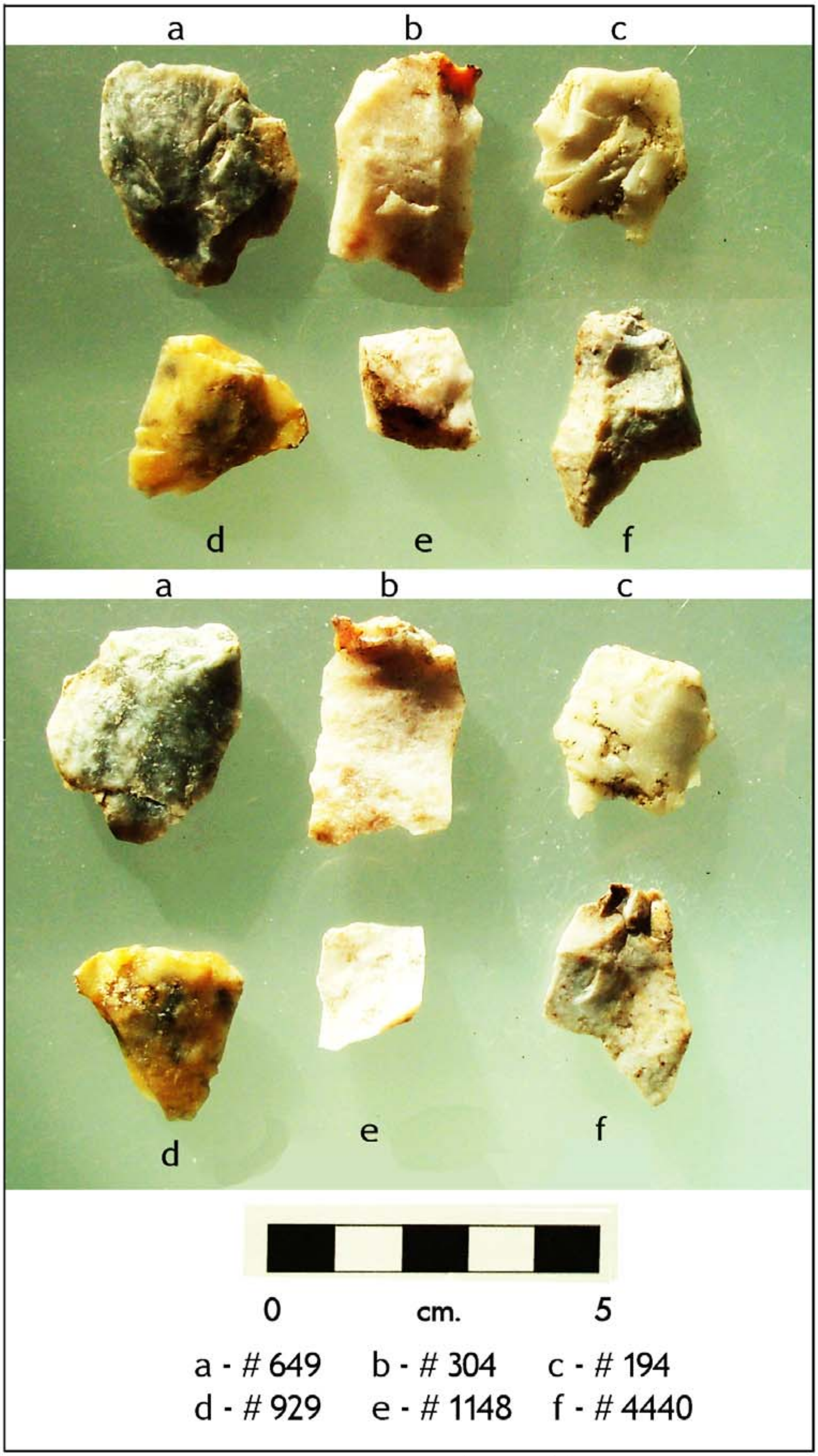
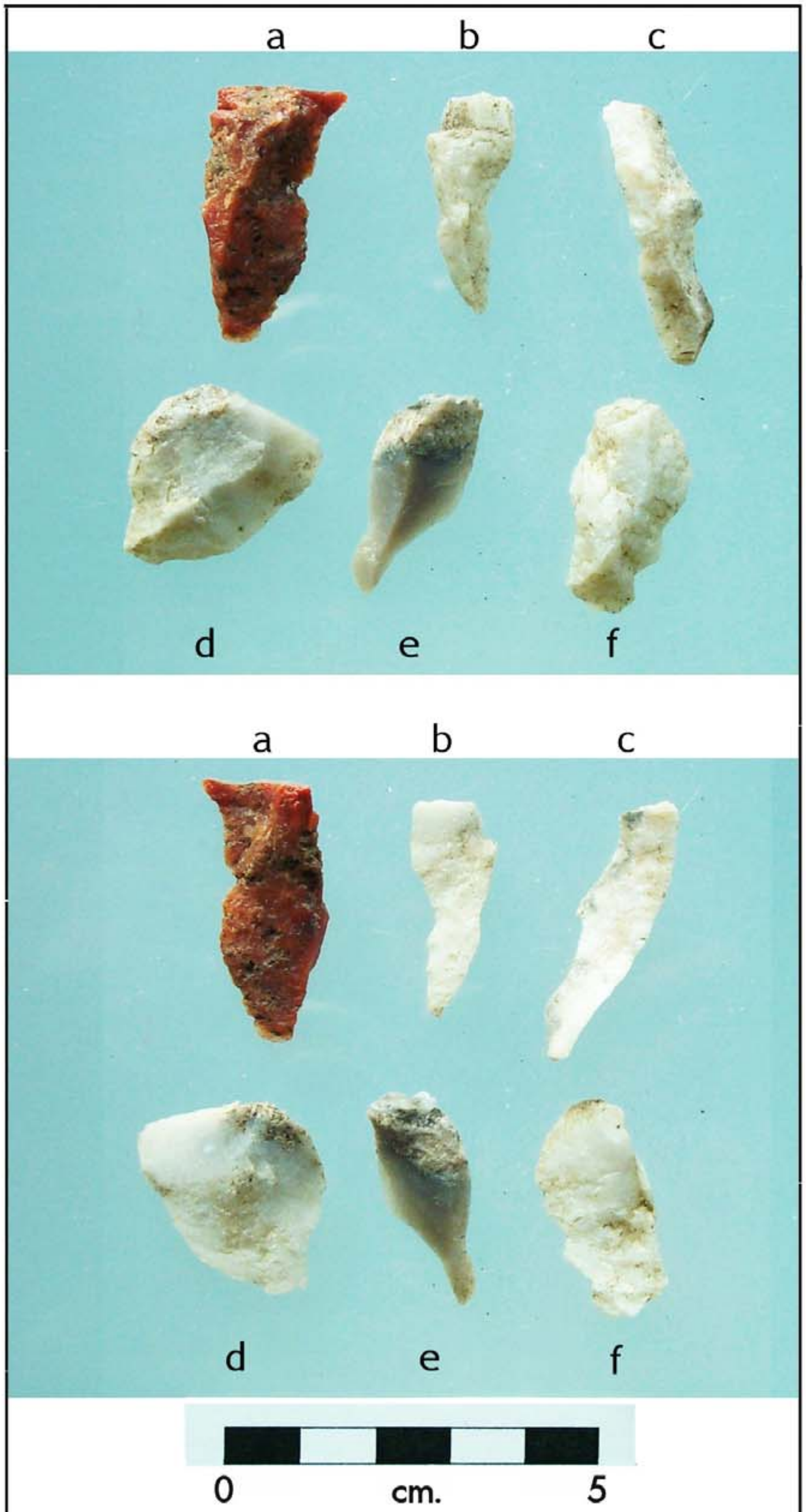


Figure A.14.7. Core reduction flakes.



a - #154 b - #1693 c - #1679
d - #309 e - #1678 f - #1684

Figure A.14.8 Shaping Flakes.

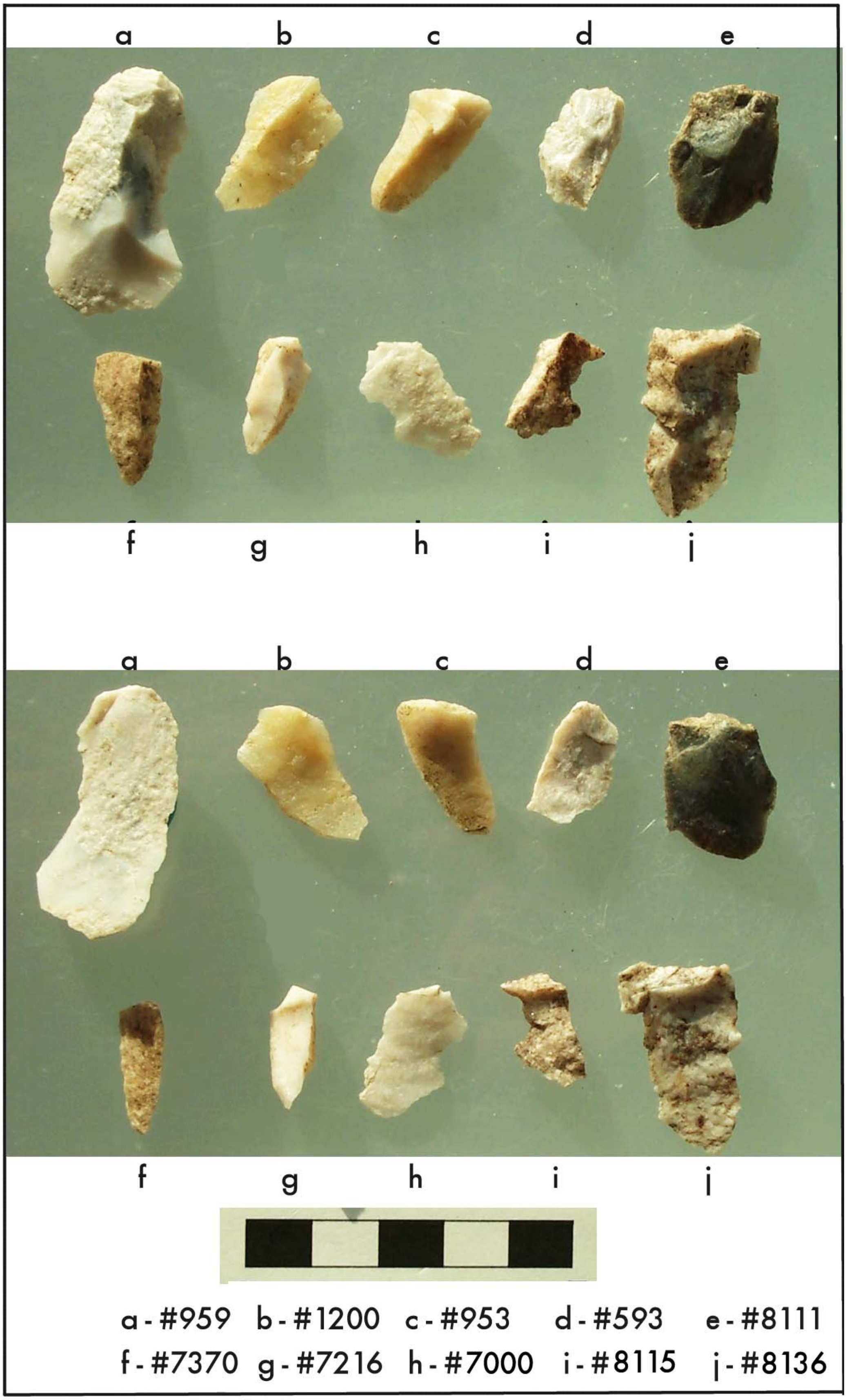


Figure A.14.9. Shaping flakes.

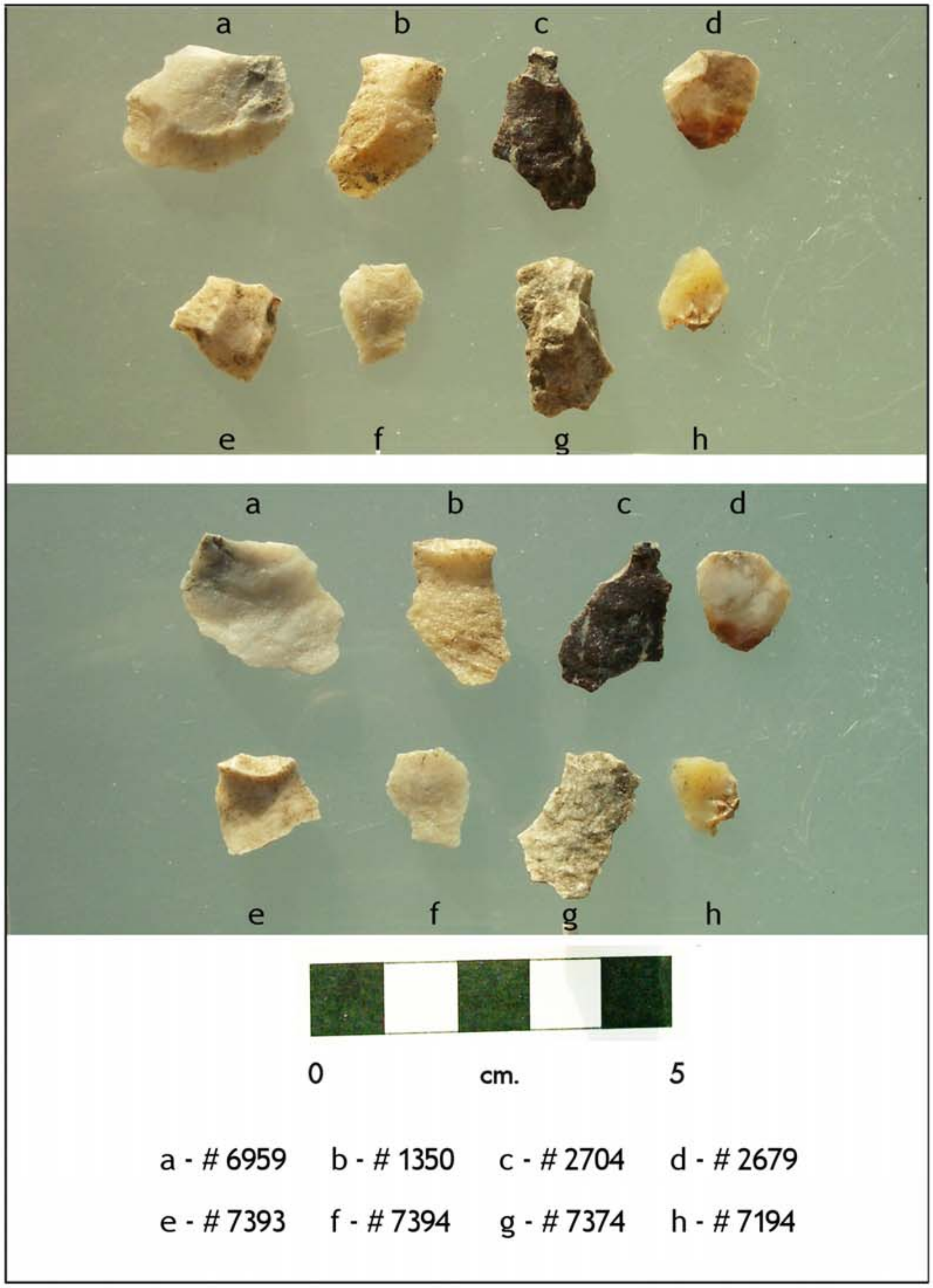


Figure A.14.10. Bifacial reduction flakes.

Appendix 15. Metrical Analysis of Complete Flakes by Type.

Table A.15.1. Metric analysis of the upper occupation.

All flake types						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	50	10	67.7	13.3	26.3	mm
Width	50	5.34	63.8	12.9	21.3	mm
Thickness	50	1.4	22.2	5.1	7	mm
Platform width	50	3.4	44.3	7.8	13.7	mm
Platform thickness	50	1.4	13.8	2.9	4.6	mm
Weight	50	0.1	62.5	15.1	8.4	g

Decortication						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	12	16.8	67.7	16.7	37.5	mm
Width	12	16.3	63.8	13.8	35.6	mm
Thickness	12	4.1	22.2	6.1	12.6	mm
Platform width	12	13.6	30.8	4.7	19	mm
Platform thickness	12	2.7	12.7	2.8	7.2	mm
Weight	12	0.9	62.5	22.3	24.7	g

Bipolar						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	4	30.5	48.6	7.7	39.6	mm
Width	4	27.8	44.3	8	34.9	mm
Thickness	4	6.8	16.9	4.4	12.3	mm
Platform width	4	17.5	44.3	11.5	27.9	mm
Platform thickness	4	4.9	13.8	4	9.1	mm
Weight	4	5.6	31.2	12.1	18.3	g

Shaping						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	20	12.1	43	7.7	23.3	mm
Width	20	8.3	25.9	5.3	15.3	mm
Thickness	20	2.3	6.5	1.2	4.8	mm
Platform width	20	3.4	17.9	4.9	10.8	mm
Platform thickness	20	1.6	5.3	1.2	3.4	mm
Weight	20	0.3	3.9	1.1	1.6	g

Bifacial reduction						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	8	10	19.4	3.5	14.2	mm
Width	8	6.4	16.3	3.4	11.8	mm
Thickness	8	2	5.1	1.1	3.3	mm
Platform width	8	3.9	13.6	3.5	8.4	mm
Platform thickness	8	1.5	4.2	1	2.5	mm
Weight	8	0.1	1.2	0.3	0.5	g

Indeterminate						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	2	15.9	20.5	3.3	18.2	mm
Width	2	9.6	21.3	8.3	15.5	mm
Thickness	2	2.8	4.1	0.9	3.5	mm
Platform width	2	5.3	10.4	3.6	7.9	mm
Platform thickness	2	1.7	2.3	0.4	2	mm
Weight	2	0.3	1.4	0.8	0.8	g

Core reduction flakes						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	3	15	40.7	13.2	26.1	mm
Width	3	5.34	29.4	13	20.3	mm
Thickness	3	6.5	8.4	1.1	7.2	mm
Platform width	3	3.7	18.3	8.3	13.3	mm
Platform thickness	3	2.7	4.9	1.2	4.1	mm
Weight	3	0.5	6.5	3	3.5	g

Sharpening flake						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	1	15.9	15.9	0	15.9	mm
Width	1	9.6	9.6	0	9.6	mm
Thickness	1	2.8	2.8	0	2.8	mm
Platform width	1	5.3	5.3	0	5.3	mm
Platform thickness	1	2.3	2.3	0	2.3	mm
Weight	1	0.3	0.3	0	0.3	g

Hard hammer						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	34	14.4	67.7	13.1	31.4	mm
Width	34	5.34	63.8	13.5	25.6	mm
Thickness	34	3.1	22.2	5.4	8.7	mm
Platform width	34	3.4	44.3	8.1	16.1	mm
Platform thickness	34	1.6	13.8	3.2	5.4	mm
Weight	34	0.4	62.5	17.2	12	g

Soft hammer						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	16	10	23.6	3.8	15.6	mm
Width	16	6.4	19	3.6	12.2	mm
Thickness	16	1.4	6.3	1.4	3.6	mm
Platform width	16	3.9	15.5	3.7	8.5	mm
Platform thickness	16	1.4	5.1	1.3	2.9	mm
Weight	16	0.1	2.1	0.6	0.7	g

Table A.15.2. Middle occupation metrics.

All flake types						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	28	10	69.8	13.2	21.0	mm
Width	28	8.7	50	11.9	19.0	mm
thickness	28	1.5	15.7	3.8	5.0	mm
Platform width	28	2.9	35.2	6.4	11.4	mm
Platform thickness	28	1.2	9	1.6	3.0	mm
Weight	28	0	32.4	8.8	4.1	g

Decortication						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	7	14.5	40.6	9.1	22.8	mm
Width	7	12.2	42.6	9.5	25.0	mm
thickness	7	3.6	15	4.0	6.6	mm
Platform width	7	7	20.5	4.2	13.0	mm
Platform thickness	7	2.2	5.5	1.2	3.3	mm
Weight	7	0	27.1	9.6	5.4	g

Bipolar flake						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	1	31.7	31.7	0.0	31.7	mm
Width	1	35.2	35.2	0.0	35.2	mm
thickness	1	11.2	11.2	0.0	11.2	mm
Platform width	1	35.2	35.2	0.0	35.2	mm
Platform thickness	1	9	9	0.0	9.0	mm
Weight	1	12.1	12.1	0.0	12.1	g

Shaping						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	8	10	24.8	4.9	18.5	mm
Width	8	8.7	25.1	5.2	14.0	mm
thickness	8	2.6	4.4	0.6	3.5	mm
Platform width	8	6.4	12.2	2.2	9.6	mm
Platform thickness	8	1.8	3.7	0.6	2.5	mm
Weight	8	0	2.1	0.6	0.8	g

Bifacial reduction						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	10	11.1	14.8	1.2	13.0	mm
Width	10	9.1	17	2.9	11.3	mm
Thickness	10	1.5	3.9	0.8	2.6	mm
Platform width	10	2.9	12.6	2.9	7.9	mm
Platform thickness	10	1.2	3.9	0.9	2.4	mm
Weight	10	0	0.7	0.2	0.3	g

Core reduction flakes						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	2	49.6	69.8	14.3	59.7	mm
Width	2	47	50	2.1	48.5	mm
thickness	2	11.8	15.7	2.8	13.8	mm
Platform width	2	14.7	22.7	5.7	18.7	mm
Platform thickness	2	3.3	5.5	1.6	4.4	mm
Weight	2	24.5	32.4	5.6	28.5	g

Hard hammer						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	12	14.5	69.8	16.4	29.7	mm
Width	12	12.2	50	12.9	28.1	mm
thickness	12	3.3	15.7	4.6	7.7	mm
Platform width	12	6.6	35.2	8.0	15.0	mm
Platform thickness	12	1.8	9	2.1	3.7	mm
Weight	12	0	32.4	11.9	9.1	g

Soft hammer						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	16	10	22.4	3.5	14.5	mm
Width	16	8.7	25.1	4.3	12.2	mm
thickness	16	1.5	4	0.8	2.9	mm
Platform width	16	2.9	12.6	2.8	8.7	mm
Platform thickness	16	1.2	3.9	0.8	2.5	mm
Weight	16	0	0.9	0.3	0.4	g

Table A.15.3. Lower occupation metrics

All complete flakes						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	663	82.5	9.8	20.4	10.4	mm
Width	663	90.5	2.9	16.4	8.9	mm
thickness	663	45.3	1.4	5.1	3.8	mm
Platform width	663	44.3	1.3	10.5	5.7	mm
Platform thickness	663	19.5	0.8	3.5	2.3	mm
Weight	663	234.5	0	3.3	11.3	g

Decortication						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	101	70.8	10.8	25.9	12.5	mm
Width	101	50.7	7.6	20.5	8.6	mm
thickness	101	24.4	2.1	7.6	4.6	mm
Platform width	101	35.6	4	12.9	6.4	mm
Platform thickness	101	19.5	0.8	4.6	3.2	mm
Weight	101	61.7	0	5.7	9.4	g

Bipolar						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	33	66.9	20.1	35.1	9.3	mm
Width	33	50	15.7	27.0	8.1	mm
thickness	33	16.9	4.9	9.2	3.0	mm
Platform width	33	33.6	7.8	16.5	6.7	mm
Platform thickness	33	15.2	2.2	5.6	2.8	mm
Weight	33	40.6	1.9	9.7	9.0	g

Core preparation flake						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	1	23.3	23.3	23.3	0.0	mm
Width	1	15.5	15.5	15.5	0.0	mm
thickness	1	9.6	9.6	9.6	0.0	mm
Platform width	1	6.2	6.2	6.2	0.0	mm
Platform thickness	1	5.6	5.6	5.6	0.0	mm
Weight	1	1.5	1.5	1.5	0.0	g

Shaping flakes						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	184	38.4	9.8	19.9	6.2	mm
Width	184	32.9	7.2	15.3	5.4	mm
thickness	184	13.3	1.6	4.6	1.9	mm
Platform width	184	24.7	2.9	9.7	4.4	mm
Platform thickness	184	13.3	1.2	3.3	1.6	mm
Weight	184	7	0	1.3	1.3	g

Bifacial reduction						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	187	25.4	10	13.3	2.8	mm
Width	187	25	2.9	11.2	3.6	mm
thickness	187	7.9	1.4	2.8	0.9	mm
Platform width	187	16	1.9	7.8	2.9	mm
Platform thickness	187	8.7	0.9	2.3	0.9	mm
Weight	187	1.9	0	0.4	0.3	g

Decortication						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	101	70.8	10.8	25.9	12.5	mm
Width	101	50.7	7.6	20.5	8.6	mm
Thickness	101	24.4	2.1	7.6	4.6	mm
Platform width	101	35.6	4	12.9	6.4	mm
Platform thickness	101	19.5	0.8	4.6	3.2	mm
Weight	101	61.7	0	5.7	9.4	g

Core reduction flakes						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	16	42.4	10.1	26.5	9.7	mm
Width	16	40.2	7.7	21.9	9.6	mm
Thickness	16	12.8	2.9	6.4	2.6	mm
Platform width	16	25.2	4	12.9	6.7	mm
Platform thickness	16	18.6	1.9	5.2	4.0	mm
Weight	16	12.2	0.2	4.0	3.2	g

Sharpening flake						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	1	20.5	20.5	20.5	0.0	mm
Width	1	12.3	12.3	12.3	0.0	mm
Thickness	1	3.1	3.1	3.1	0.0	mm
Platform width	1	4.9	4.9	4.9	0.0	mm
Platform thickness	1	2.8	2.8	2.8	0.0	mm
Weight	1	0.6	0.6	0.6	0.0	g

Thinning flake						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	1	16	16	16.0	0.0	mm
Width	1	9.5	9.5	9.5	0.0	mm
thickness	1	1.7	1.7	1.7	0.0	mm
Platform width	1	2.4	2.4	2.4	0.0	mm
Platform thickness	1	1.5	1.5	1.5	0.0	mm
Weight	1	0.2	0.2	0.2	0.0	g

All hard hammer						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	232	70.8	11	26.6	10.3	mm
Width	232	50.7	8.1	20.8	8.1	mm
thickness	232	24.4	2.2	7.1	3.7	mm
Platform width	232	35.6	4	12.7	6.3	mm
Platform thickness	232	19.5	1.3	4.5	2.9	mm
Weight	232	61.7	0	4.9	7.6	g

All soft hammer complete flakes						
	Freq.	Min.	Max.	St. Dev.	Mean	Measure
Length	300	35.4	9.8	14.6	4.1	mm
Width	300	26.1	2.9	11.8	3.8	mm
thickness	300	7.9	1.4	3.1	1.2	mm
Platform width	300	19.9	1.9	8.3	3.3	mm
Platform thickness	300	8.7	0.8	2.6	1.2	mm
Weight	300	5.5	0	0.5	0.5	g

Appendix 16. Platform Shape.

Table A.16.1. Platform shapes of the upper occupation.

Upper Occupation			
Platform Shape	Total	Hard Hammer	Soft Hammer
Crescent	2	2	0
Diamond	2	1	1
Discoidal	16	13	3
Oval	18	11	7
Triangular	12	7	5
Total	50	34	16

Upper Occupation			
Platform Shape	Total	Hard Hammer	Soft Hammer
Crescent	4%	6%	0%
Diamond	4%	3%	6%
Discoidal	32%	38%	19%
Oval	36%	32%	44%
Triangular	24%	21%	31%
Total	50	34	16

Upper Occupation				
Platform Shape	SRC	Indet. Chert	Quartzite	Limestone
Crescent	1	1	0	0
Diamond	2	0	0	0
Discoidal	15	0	0	1
Oval	16	1	1	0
Triangular	12	0	0	0
Total	46	2	1	1
Upper Occupation				
Platform Shape	SRC	Indet. Chert	Quartzite	Limestone
Crescent	2%	50%	0%	0%
Diamond	4%	0%	0%	0%
Discoidal	33%	0%	0%	100%
Oval	35%	50%	100%	0%
Triangular	26%	0%	0%	0%
Total	46	2	1	1

Upper Occupation						
Platform Shape	1° and 2° Decort.	3° Decort.	Bipolar	Core-Reduction	Shaping	Bifacial Reduction
Crescent	0	0	0	0	2	0
Diamond	0	1	0	0	0	1
Discoidal	1	5	3	1	3	2
Oval	3	0	1	1	8	3
Triangular	2	0	0	1	7	2
Total	6	6	4	3	20	8
Upper Occupation						
Platform Shape	1° and 2° Decort.	3° Decort.	Bipolar	Core-Reduction	Shaping	Bifacial Reduction
Crescent	0%	0%	0%	0%	10%	0%
Diamond	0%	17%	0%	0%	0%	13%
Discoidal	17%	83%	75%	33%	15%	25%
Oval	50%	0%	25%	33%	40%	38%
Triangular	33%	0%	0%	33%	35%	25%
Total	6	6	4	3	20	8

Table A.16.2. Platform shapes of the middle occupation.

Middle Occupation			
Platform Shape	Total	Hard Hammer	Soft Hammer
Crescent	1	0	1
Diamond	1	0	1
Discoidal	5	2	3
Oval	15	7	8
Triangular	6	3	3
Total	28	12	16

Middle Occupation			
Platform Shape	Total	Hard Hammer	Soft Hammer
Crescent	4%	0%	6%
Diamond	4%	0%	6%
Discoidal	18%	17%	19%
Oval	54%	58%	50%
Triangular	21%	25%	19%
Total	28	12	16

Middle Occupation					
Platform Shape	SRC	Indet. Chert	RRC	Gronlid	Red Willow
Crescent	1	0	0	0	0
Diamond	1	0	0	0	0
Discoidal	4	0	1	0	0
Oval	13	1	0	1	0
Triangular	5	0	0	0	1
Total	24	1	1	1	1

Middle Occupation					
Platform Shape	SRC	Indet. Chert	RRC	Gronlid	Red Willow
Crescent	4%	0%	0%	0%	0%
Diamond	4%	0%	0%	0%	0%
Discoidal	17%	0%	100%	0%	0%
Oval	54%	100%	0%	100%	0%
Triangular	21%	0%	0%	0%	100%
Total	24	1	1	1	1

Middle Occupation						
Platform Shape	1° and 2° Decort.	3° Decort.	Bipolar	Core-Reduction	Shaping	Bifacial Reduction
Crescent	0	0	0	0	1	0
Diamond	0	0	0	0	0	1
Discoidal	1	1	0	0	1	2
Oval	4	0	0	2	2	7
Triangular	1	0	1	0	4	0
Total	6	1	1	2	8	10

Middle Occupation						
Platform Shape	1° and 2° Decort.	3° Decort.	Bipolar	Core-Reduction	Shaping	Bifacial Reduction
Crescent	0%	0%	0%	0%	13%	0%
Diamond	0%	0%	0%	0%	0%	10%
Discoidal	17%	100%	0%	0%	13%	20%
Oval	67%	0%	0%	100%	25%	70%
Triangular	17%	0%	100%	0%	50%	0%
Total	6	1	1	2	8	10

Table A.16.3. Platform shapes of the lower occupation.

Lower Occupation			
Platform Shape	Total	Hard Hammer	Soft Hammer
Crescent	30	12	18
Diamond	20	7	13
Discoidal	122	74	48
Oval	199	61	138
Triangular	138	71	67
Rectangular	16	3	13
Indeterminate	7	4	3
Total	532	232	300

Lower Occupation			
Platform Shape	Total	Hard Hammer	Soft Hammer
Crescent	6%	5%	6%
Diamond	4%	3%	4%
Discoidal	23%	32%	16%
Oval	37%	26%	46%
Triangular	26%	31%	22%
Rectangular	3%	1%	4%
Indeterminate	1%	2%	1%
Total	532	232	300

Lower Occupation												
Platform Shape	SRC	Indet. Chert	RRC	Gronlid	Red Willow	Basalt	Qtz	Qite	Limestone	Siltstone	Chalcedony	Jasper
Crescent	25	0	0	0	0	1	1	2	1	0	0	0
Diamond	19	0	0	0	0	0	0	0	0	0	1	0
Discoidal	102	1	1	2	2	1	3	4	0	3	1	0
Oval	179	0	1	1	0	1	2	7	4	3	0	1
Triangular	125	0	1	0	0	2	0	8	0	2	0	0
Rectangular	13	0	0	0	0	1	0	2	0	0	0	0
Indeterminate	7	0	0	0	0	0	0	0	0	0	0	0
Total	470	1	3	3	2	6	6	23	5	8	2	1

Lower Occupation												
Platform Shape	SRC	Indet. Chert	RRC	Gronlid	Red Willow	Basalt	Qtz	Qite	Limestone	Siltstone	Chalcedony	Jasper
Crescent	5%	0%	0%	0%	0%	17%	17%	9%	20%	0%	0%	0%
Diamond	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%
Discoidal	22%	100%	33%	67%	100%	17%	50%	17%	0%	38%	50%	0%
Oval	38%	0%	33%	33%	0%	17%	33%	30%	80%	38%	0%	100%
Triangular	27%	0%	33%	0%	0%	33%	0%	35%	0%	25%	0%	0%
Rectangular	3%	0%	0%	0%	0%	17%	0%	9%	0%	0%	0%	0%
Indeterminate	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	470	1	3	3	2	6	6	23	5	8	2	1

Lower Occupation								
Platform Shape	1° and 2° Decort.	3° Decort.	Bipolar	Core-Reduction	Shaping	Bifacial Reduction	Unifacial Reduction	Thinning
Crescent	1	4	1	0	11	10	0	0
Diamond	0	1	0	1	8	9	0	1
Discoidal	23	19	10	5	34	31	0	0
Oval	21	16	6	4	52	96	1	1
Triangular	7	8	16	2	76	25	2	0
Rectangular	1	1	0	0	1	13	0	0
Indeterminate	0	1	0	1	2	3	0	0
Total	52	50	33	13	184	187	3	2

Lower Occupation								
Platform Shape	1° and 2° Decort.	3° Decort.	Bipolar	Core-Reduction	Shaping	Bifacial Reduction	Unifacial Reduction	Thinning
Crescent	2%	8%	3%	0%	6%	5%	0%	0%
Diamond	0%	2%	0%	8%	4%	5%	0%	50%
Discoidal	44%	38%	30%	38%	18%	17%	0%	0%
Oval	40%	32%	18%	31%	28%	51%	33%	50%
Triangular	13%	16%	48%	15%	41%	13%	67%	0%
Rectangular	2%	2%	0%	0%	1%	7%	0%	0%
Indeterminate	0%	2%	0%	8%	1%	2%	0%	0%
Total	52	50	33	13	184	187	3	2

Appendix 17. Size Grade Analysis Data.

Table A.17.1. Type one size grade.

Frequency			
Size Grade	Gronlid	Chalcedony	Red Willow
G1	3	3	7
G2	18	11	22
G3	23	9	16
G4	173	39	55
Total	217	62	100

Weight			
Size Grade	Gronlid	Chalcedony	Red Willow
G1	4.6	4.6	20.5
G2	10.9	6.9	38.5
G3	3.4	1.6	4
G4	6.7	1	2.9
Total	25.6	14.1	65.9

	Percentages by Frequency		
Size Grade	Gronlid	Chalcedony	Red Willow
G1	1%	5%	7%
G2	8%	18%	22%
G3	11%	15%	16%
G4	80%	63%	55%

	Percentages by Weight		
Size Grade	Gronlid	Chalcedony	Red Willow
G1	18%	33%	31%
G2	43%	49%	58%
G3	13%	11%	6%
G4	26%	7%	4%

Table A.17.2. Type two size grade.

Frequency						
Size Grade	SRC	Qtz.	Basalt	Qite	Siltstone	Sil. Wood.
G1	1003	14	4	37	11	1
G2	2898	25	13	71	27	2
G3	3072	15	10	68	17	1
G4	13440	93	22	313	32	2
Total	20413	147	49	489	87	6

Weight						
Size Grade	SRC	Qtz.	Basalt	Qite	Siltstone	Sil. Wood.
G1	4601.8	72.9	10.9	239.8	35.8	1.5
G2	1885.1	15.5	5.2	57.5	15.4	1
G3	525.7	3.8	2.9	15.4	3.8	0.2
G4	627.7	4.1	1.7	17.2	2	0
Total	7640.3	96.3	20.7	329.9	57	2.7

Percentages by Frequency						
Size Grade	SRC	Qtz.	Basalt	Qite	Siltstone	Sil. Wood.
G1	5%	10%	8%	8%	13%	17%
G2	14%	17%	27%	15%	31%	33%
G3	15%	10%	20%	14%	20%	17%
G4	66%	63%	45%	64%	37%	33%

Percentages by Weight						
Size Grade	SRC	Qtz.	Basalt	Qite	Siltstone	Sil. Wood.
G1	60%	76%	53%	73%	63%	56%
G2	25%	16%	25%	17%	27%	37%
G3	7%	4%	14%	5%	7%	7%
G4	8%	4%	8%	5%	4%	0%

Table A.17.3 Type three size grade.

Frequency		
Size Grade	RRC	Silicified Peat
G1	6	0
G2	14	0
G3	17	1
G4	93	3
Total	130	4
Weight		
Size Grade	RRC	Silicified Peat
G1	3.8	0
G2	2.4	0
G3	5.9	0.2
G4	17.1	0.2
Total	29.2	0.4

Percentages by Frequency		
Size Grade	RRC	Silicified Peat
G1	5%	0%
G2	11%	0%
G3	13%	25%
G4	72%	75%

Percentages by Weight		
Size Grade	RRC	Silicified Peat
G1	13%	0%
G2	8%	0%
G3	20%	50%
G4	59%	50%

Appendix 18. Metrical Analysis of Tools.

Table A.18.1. Measuments of individual tools.

Cat. #	Level	Tool Type	Length in mm.	Width in mm.	Thickness in mm.
5858	10	Anvil			
3932	9	Biface	44.75	33.02	15.36
11078	9	Biface	33.06	28.77	8.74
1156	10	Biface Fragment	34.60	16.08	9.25
3366	10	Biface Fragment	48.94	32.35	14.78
5061	10	Biface Fragment	28.38	28.50	9.38
5449	9	Biface Fragment	39.09	20.89	11.66
5821	10	Biface Fragment	34.26	18.34	8.15
5897	10	Biface Fragment	34.94	29.83	9.01
6689	10	Biface Fragment	37.43	19.75	8.57
7125	5	Biface Fragment	41.65	29.83	14.71
7990	10	Biface Fragment	42.44	33.23	16.15
2638	10	Chithos	79.41	72.22	22.54
2663	10	Endscraper	32.48	21.70	11.31
5060	10	Endscraper	16.80	19.83	6.98
7869	9	Endscraper	31.79	25.14	9.57
5898	10	Hammerstone			
8250	2	Hammerstone			
10017	3	Hammerstone			
9076	9	Hammerstone/Anvil			
5818	10	Multipurpose Tool	104.27	91.15	31.85
7855	9	Piece Esquillees	30.43	15.76	8.65
4144	10	Projectile Point	25.06	17.68	5.13
11076	9	Projectile Point	23.46	15.96	5.41
11077	9	Projectile Point	29.91	15.69	4.97
10657	10	Retouched Shatter	28.54	25.44	14.67
747	10	Retouched Flake	11.98	9.01	2.25
778	9	Retouched Flake	10.48	6.67	3.29
779	10	Retouched Flake	21.26	14.55	4.77
1976	10	Retouched Flake	28.84	15.22	5.14
2029	10	Retouched Flake	18.02	11.67	4.01
2671	10	Retouched Flake	18.61	9.74	3.11
4235	10	Retouched Flake	23.27	11.02	4.85

Cat. #	Level	Tool Type	Length in mm.	Width in mm.	Thickness in mm.
4305	10	Retouched Flake	22.43	14.37	3.38
5033	10	Retouched Flake	50.71	22.73	13.72
5058	10	Retouched Flake	40.45	21.23	3.57
5059	10	Retouched Flake	32.34	23.34	8.19
5303	8	Retouched Flake	18.79	14.47	6.91
7138	6	Retouched Flake	16.91	6.58	3.98
7466	1	Retouched Flake	18.58	15.22	5.20
7675	8	Retouched Flake	34.02	12.03	3.17
7854	9	Retouched Flake	18.23	9.01	4.43
7972	10	Retouched Flake	29.82	23.19	6.44
8391	8	Retouched Flake	14.93	13.28	3.24
8530	9	Retouched Flake	33.40	30.66	8.19
8595	10	Retouched Flake	35.38	20.60	5.98
9517	8	Retouched Flake	39.94	21.73	9.33
6093	7	Retouched Flake	19.53	14.56	4.05
4161	10	Retouched Flake (refits w 4157)	21.22	10.13	4.90
4157	10	Retouched Flake (refits w 4161)	18.66	14.32	4.69
1153	10	Reverse Uniface	40.58	33.98	9.41
4236	10	Reverse Uniface	41.16	28.41	7.79
5062	10	Reverse Uniface	51.47	38.76	15.32
11075	11	Reverse Uniface	22.80	29.17	5.21
3135	7	Sidescraper	45.13	21.80	18.56
4231	10	Sidescraper	49.45	29.78	10.53
813	7	Uniface Fragment	20.76	13.80	4.93
9322	10	Utilized Flake	44.05	21.03	4.02

Table A.18.2. Projectile point metrics following Brumley (1988).

Brumley's Abbreviations	Catalogue Number	4144	11076	11077
	Material Type	Heated SRC	Heated SRC	Heated SRC
a	Body Length	17.7	Na	18.3
b	Stem Length	7.4	Na	11.6
ab	Total Length	25.1	23.5	29.9
c	Max Body Width	17.7	16.0	15.7
d	Shoulder Width	17.7	Na	15.7
e	Max Stem Width	15.3	Na	12.7
f	Min Stem Width	12.5	Na	8.5
g	Base Width	15.3	Na	7.7
h	Width of Notch	2.92rt/3.72lt	Na	Na
I	Depth of Notch	3.43rt/2.11lt	Na	Na
j	Height of Basal Edge	3.8	16.0	5.4
k	Max Body Thickness	5.1	15.7	5.0
l	Max Stem Thickness	4.4	Na	4.9

Appendix 19. Tool Analysis.

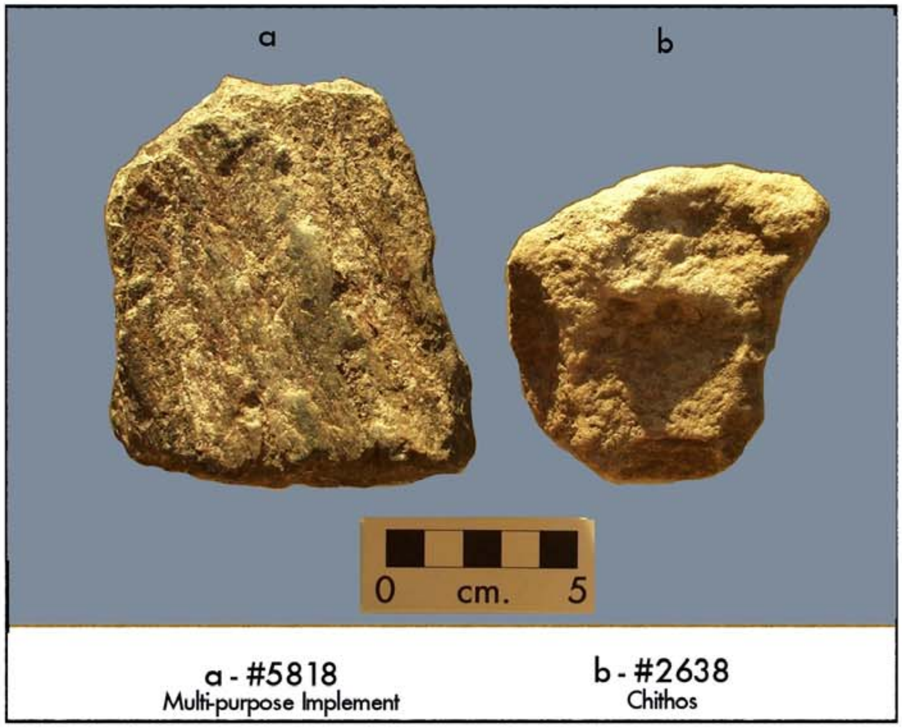


Figure A.19.1. Multi-purpose implement and possible chithos.

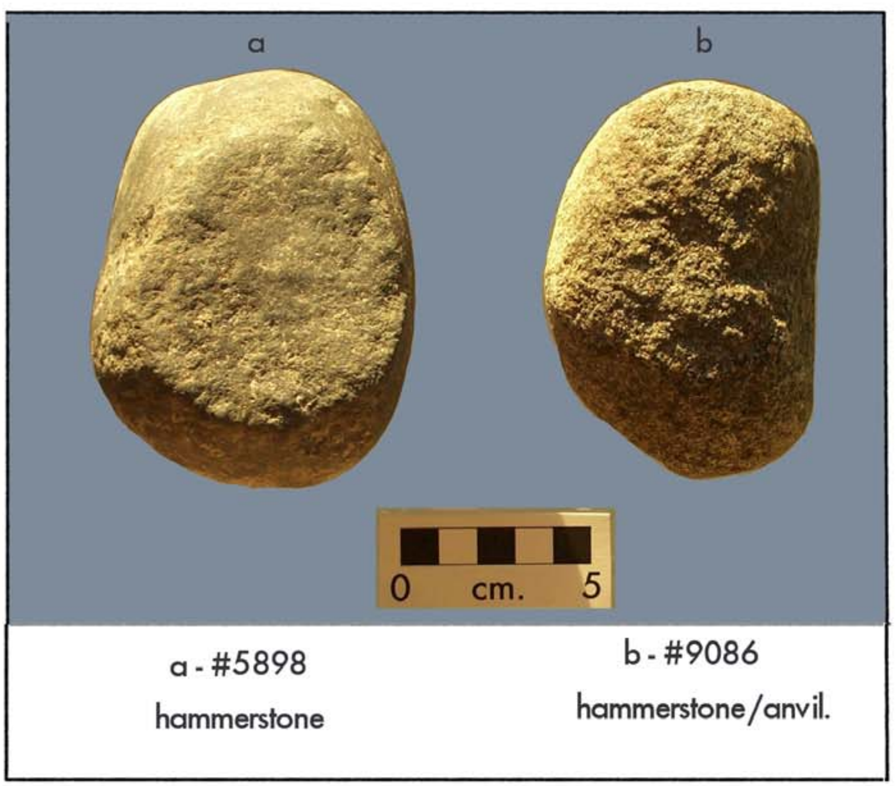


Figure A.19.2. Hammerstones from the lower occupation.

Figure 19.3. Anvil from the lower occupation. (#5858)

Appendix 19.2. Tool Analysis: Manufacture of Individual Implements.

Artifact number 3135 is a complete unifacially retouched bipolar core, with usewear. It has been manufactured from thermally altered Swan River chert. Some cortex is present. One edge of the bipolar core had primary pressure flaking done to create an edge. Small flakes on the ventral surface indicate usewear, where the item was used as a sidescraper.

Artifact number 11075 is a complete reverse endscraper manufactured from thermally altered Swan River chert. A hard hammer decortication flake has been removed from a core, the dorsal surface was shaped with soft hammer percussion flaking (technically unifacial reduction, but due to the form and edge such flakes are indistinguishable from bifacial reduction). Later, the distal edge was pressure flaked to create the working edge with both primary and secondary pressure retouch. The idea behind the scraper was to have the cortex as the ventral surface, hence a reverse scraper. The item lacks evidence of usewear and bipolar methods.

Artifact number 11076 is a broken tip of a projectile point fabricated from thermally altered Swan River chert. The original shaping of the item was through bifacial reduction along the lateral margins of both surfaces. On the dorsal surface, primary and secondary pressure reduction occurred along the entire edge. On the ventral surface, Primary retouch occurred along the tip and left lateral edge, secondary retouch occurred on the tip only. The item was broken by a step fracture, probably occurred during manufacture (evident by the lack of primary retouch on the ventral surface, that the point was never finished).

Artifact number 11077 is a nearly complete projectile point manufactured from thermally altered Swan River chert. Original forming was by shaping flakes on both dorsal and ventral surfaces, bifacial reduction occurred only on the ventral surface. Primary pressure retouch occurred along the edge above the shoulder. Secondary retouch on the dorsal surface occurred along the tip, and on the ventral surface along the left lateral edge of the tip. The item has a stemmed appearance due to breakage of the base. The piece has a twisting latitudinal cross-section (such asymmetry was characteristic of some Terminal Plano projectiles).

Artifact number 11078 is a complete triangular bifacial knife of thermally altered Swan River chert. The item had original hard hammer shaping on the dorsal surface, and general forming of both surfaces with bifacial reduction. The dorsal surface exhibits slight primary pressure retouching on the right lateral edge. On the ventral surface, primary pressure retouch occurred along the proximal edge and proximal/right lateral edge. The cross section is bi-convex.

Artifact number 9517 is a unifacially-retouched flake of thermally altered Swan River chert. Slight unifacial reduction of the dorsal surface has occurred along the distal edge. Primary and secondary pressure retouch occurred along the distal edge. Usewear is present as slight step fractures along the distal edge. It item was used as an endscraper. The cross section is rectangular.

Artifact number 9322 is a complete utilized hard hammer shaping flake of Red River chert. Slight usewear is present along the left lateral edge on the ventral surface. The flake is a hard hammer percussion flake of very nice Red River chert. The usewear consists of small step fractures and the occasional larger flake scar. The item was used as a knife. The cross section is bi-convex.

Artifact number 5897 is a broken biface manufactured from thermally altered Swan River chert. The bifaces was originally formed on an item with remnant shaping flakes. The bifaces was formed with bifacial reduction flakes. The exterior edge has been thinned with primary pressure retouch, and in places, secondary pressure retouch. The implement is broken by step fractures in three locations, with evidence of primary pressure retouch past the break, indicating that the item broke after the edge was made. Usewear is present along the area of secondary pressure retouch. The item functioned as a knife.

Artifact number 5821 is a fragment of a biface manufactured of thermally altered Swan River chert. The bifaces is of unsure manufacture due to breakage. Shaping removals are present, as are bifacial reduction flake scars. Primary pressure retouch occurred on the ventral surface. The item is broken by two step fractures. There was no evidence of use. Therefore it is likely that the biface broke during manufacture.

Artifact number 7675 is a unifacially retouched flake of thermally altered Swan River chert. The item had primary and secondary pressure retouching along the right lateral edge of a complete hard hammer shaping flake. Very obvious usewear is present as small step fractures occur along both faces of the right lateral edge. The item has a fully formed edge on a complete flake. The item was used as a unifacial knife, the usewear supports the interpretation. The item has a triangular cross section.

Artifact number 4236 is a complete reverse uniface on a bipolarly split quartzite pebble. It is a small version of the reverse uniface associated with Early Side-notched sites. This implement was used as an end-sidescraper. The original piece is a bipolar primary decortification flake. Unifacial reduction flakes were removed from the distal edge (on the ventral surface). Secondary pressure retouch and general smoothing from usewear is present along the distal edge and left lateral margins. The item is complete, the step fracture was from bipolar reduction.

Artifact number 1153 is a complete reverse uniface on a bipolarly split quartzite pebble of Early Side-notched antiquity. The item has been used as an endscraper, the form and extensive retouch of utilization evidence for this. The original piece was a bipolarly removed primary decortication flake. A few shaping flakes were removed from the ventral surface of the objective piece. Unifacial reduction is present along the distal edge. A few pressure retouch flakes are also removed on that edge. Extensive usewear is present along the distal edge - small step fractures are common and extensive, with some smoothing. The step fracture along the right lateral edge was from the bipolar reduction of the objective piece. [An idea of the bipolar reverse uniface is that the main unifacial reduction occurred along the former bipolar platform].

Artifact 2663 is a complete endscraper of thermally altered Swan River chert. The item was fabricated on a hard hammer percussion flake. Some residual shaping of the objective piece (past core-reduction) is present. Unifacial reduction has occurred along the distal portion of both lateral margins. Primary pressure retouch and tiny step fracture usewear occur along the distal edge. The item is complete, and was used as an endscraper, the form and usewear indicate this. The cross section is plano-convex.

Artifact 5499 is a biface fragment of thermally altered Swan River chert. The surface of the objective piece was formed by bifacial reduction and primary pressure retouch on both dorsal and ventral surfaces. Secondary pressure retouch and slight step fracture usewear is present along the lateral edge. The biface broke after the item was used. From the usewear, the item was used as a bifacial knife

Artifact 4231 is a complete end-sidescraper of thermally altered Swan River chert. The item has been formed on an indeterminate hard hammer decortification flake. The objective piece had some shaping flakes removed during core-reduction. Unifacial reduction occurred along the distal edge. Primary, secondary pressure retouch, and small step fracture usewear are present along the dorsal surface of the left lateral edge. Small broader usewear flake scars are present on the ventral surface. The item was used as an end-sidescraper.

Artifact 4305 is a fragment of a bifacially retouched flake of thermally altered Swan River chert. The left lateral edge had primary pressure retouch on both dorsal and ventral surfaces. Slight step fractures usewear are present along the left lateral edge. The implement was used in a cutting manner. The cross section is rectangular.

Artifact 5062 is a reverse end-sidescraper manufactured on a pebble chert. The reverse form is characteristic of Early Side-notched antiquity, the sidescraper form is unusual. The objective pebble was initially fashioned with hard hammer decortification flakes. The distal edge and distal portion of both lateral edges were fashioned with unifacial reduction flakes. The distal and left lateral edge exhibits small flake scars on both surfaces from usewear. The item was used as an end-sidescraper for working hide and other organic materials. The cross section is plano-convex.

Artifact 7855 is a complete pièce esquillées of an indeterminate black chert with cortex. The objective piece was bidirectionally produced with hard hammer shaping flakes; the ventral surface exhibits one bifacial reduction flake scar, while primary pressure occurs along the lateral margins of both dorsal and ventral surfaces. Heavy grinding/crushing usewear is present on the lateral margins. From the literature review, the item was likely used for working organic materials (especially soft wood). The cross section is rectangular (nearly square) near the proximal surface and biconvex by the distal face.

Artifact number 1156 is a fragment of a biface made on thermal altered Swan River chert. The piece of chert was originally formed with hard hammer shaping on both surfaces. Some bifacial reduction are present on the ventral surface. Wide-step-fracture usewear is present along the distal edge. The item has been broken by step fractures in three places: along the right lateral margin, the left lateral margin and at the proximal edge. The implement was used as a bifacial knife before breakage.

Artifact 3366 is a fragment of a biface manufactured from thermally altered Swan River chert with cortex present. The biface was initially thinned by hard hammer decortication flakes. The dorsal surface retain bifacial reduction flake scars along the left lateral and distal edges. The entire ventral surface shows decortification, shaping flake scars, with primary pressure retouch along the right lateral edge. Tiny-step-fractures indicate usewear along the right and distal edges. The item is broken along the proximal edge by a step fracture. Since there is usewear, the item was likely broken after use. The item was used as a knife, and broken after utilization. Of note is that all the flake scars on the ventral surface terminated with step fractures. The cross section is biconvex.

Artifact 5061 is a biface fragment manufactured from thermally altered Swan River chert. The objective piece was shaped by bifacial reduction on both surfaces. Primary pressure retouch occurs along the right lateral margin on both surfaces. A moderate amount of fine-step-fractures of usewear occurs along the distal and right lateral edge. The item was used as a knife, and broke along the proximal edge after utilization.

Artifact 6689 is a fragment of a biface manufactured on thermally altered Swan River chert. The implement was formed by initial core reduction on the dorsal surface, shaping on the ventral surface, and some bifacial reduction along the right lateral margin. Significant step fractures are present along the dorsal surface of the right lateral margin. They relate to manufacture and not to use. The item is broken by step fractures along the proximal and distal ends. There is no direct evidence of use; therefore, the item likely broke during manufacture. The cross section is biconvex.

Artifact 7125 is a biface fragment fabricated of thermally altered Swan River chert. Initial hard hammer shaping formed the item. Bifacial reduction occurs on the margins of both surfaces. Usewear is present as either "secondary" retouch and/or small flake scars along the distal edge and the proximal right corner. The item is broken on the right lateral margin after use. The item was used as a knife.

Artifact 7990 is a broken biface manufactured of quartz. Shaping flakes on both surfaces formed the item. The central surface has bifacial reduction along the right lateral edge. Primary pressure retouch flake scars occur on both surfaces of the right lateral edge. The edge exhibits usewear as smoothing and tiny-step-fractures along the ventral surface. The item was broken along the proximal edge after manufacture and use. The item was used a knife.

Artifact 7869 is a broken endscraper manufactured of thermally altered Swan River chert. The implement was only formed on the dorsal surface. Initial shaping as occurred over the entire surface, while unifacial reduction, primary and secondary pressure retouch has occurred along the right and distal edge. Usewear is present as smoothing and tiny-step-fractures along the dorsal surface of the working edge. Very slight usewear occurs on the ventral surface. The item is broken along the proximal and left lateral edge, likely occurred after use. Even broken, this scraper was still functional. The item was used as an end-sidescraper for the processing of organic materials.

Artifact 5060 is a fragment of an endscraper of thermally altered Swan River chert. The item was manufactured from a hard hammer decortification flake. All modification occurred on the dorsal surface. One shaping flake was placed along the left lateral edge, the distal edge was formed by unifacial reduction and primary pressure retouch. Small-step-fracture usewear occurs along the distal and lateral edges. The item was broken on the proximal edge after manufacture and use. The item was used as a scraper of organic materials.

Artifact 813 is a fragment of an indeterminate type of uniface manufactured of thermally altered Swan River chert. Flaking has only occurred on the dorsal surface.

Evidence of hard hammer shaping is present. Primary pressure retouch is evident on the lateral margins. Usewear occurs along the left lateral edge as smoothing, while tiny-step-fracture are present along the right lateral edge. The item was broken along the proximal and right lateral edge, likely after manufacture. The use of the implement is unknown due to breakage. The cross section is plano-convex.

Artifact 2638 is a complete sandstone chithos/techua. The distal edge of the piece has been ground from use. The item was as a heavy scraper of organic materials. The best evidence supporting the interpretation of the object as a tool is its context in the centre of a living floor.

Artifact 5818 is a complete multipurpose pecked and ground stone tool manufactured of gneiss. The item had some hard hammer decortication flake removals from the proximal and lateral edges on both surfaces. The ventral surface has been smoothed and ground through use as an abrader. The distal edge shows pecking indicative of hammering, the proximal edge has pecking and wear from use as a chopper. Therefore, the implement was used as a hammerstone, chopper, and abrader.

Appendix 20. Photography of Cores.

amorphous cores

a - # 8697 b - # 7499

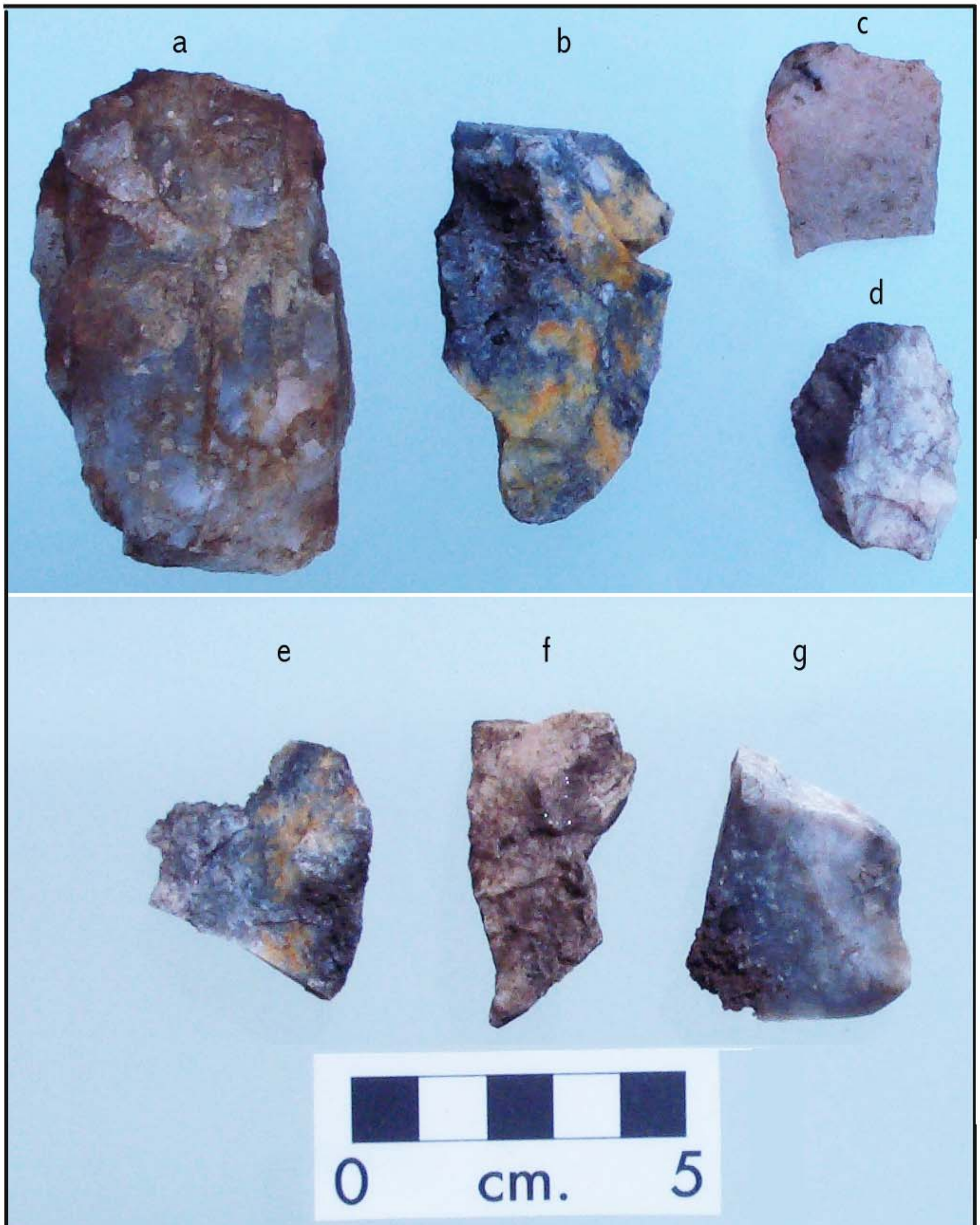
c - # 7503 d - # 8742 e - # 3618

bifacial cores

f - # 8227 g - # 10015 h - # 8142

i - # 7500 j - # 4437 k - # 4491

Figure A.20.1. Upper occupation amorphous and bifacial cores.



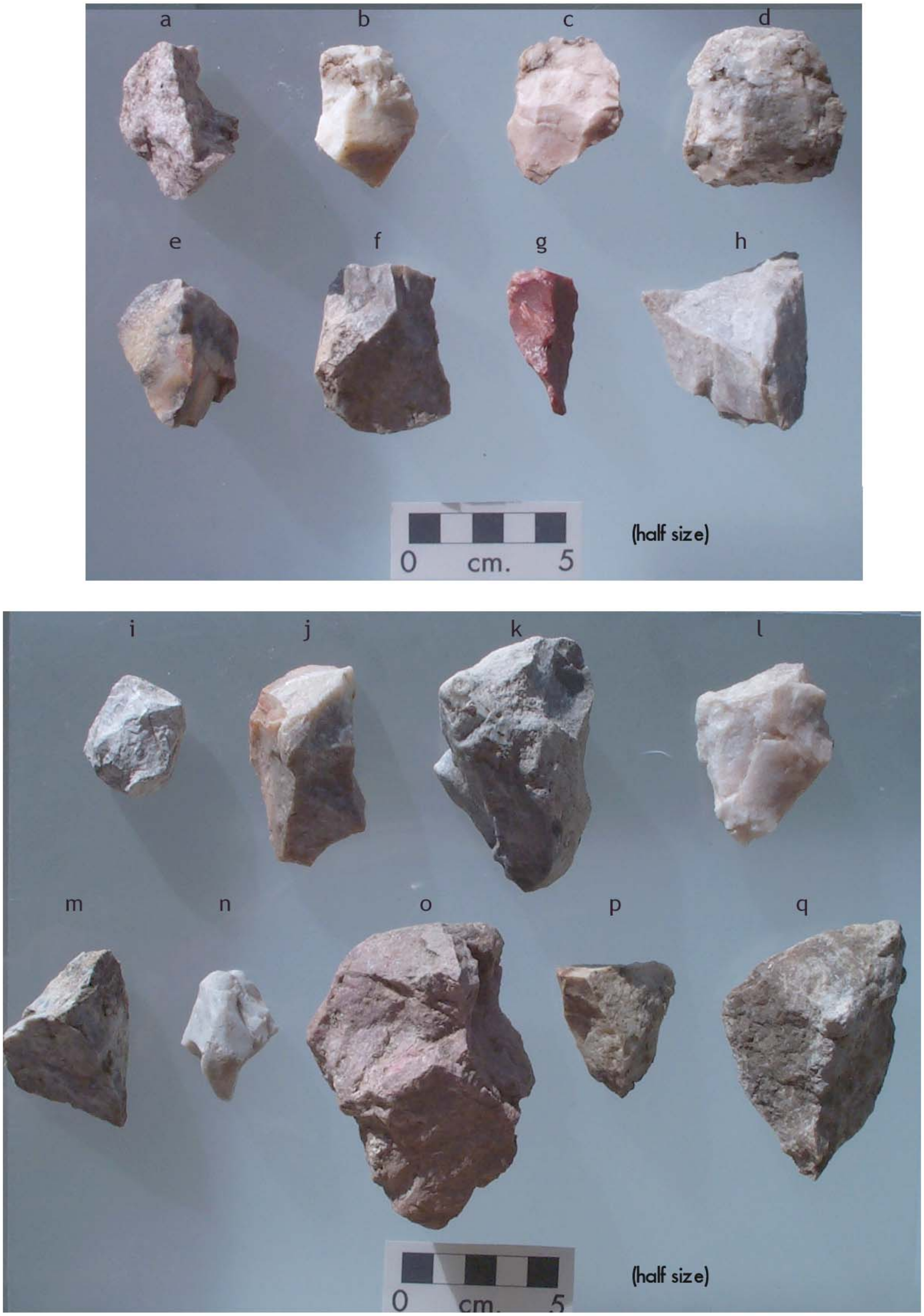
a - Bipolar #8700 b - Bipolar #8747 c - Flake Core #7691 d - Core Frag #9372

e - Bifacial #5085 f - Bifacial Core Frag #1223 g - Bifacial Core Frag #8191

Figure A.20.2. Upper occupation miscellaneous cores.

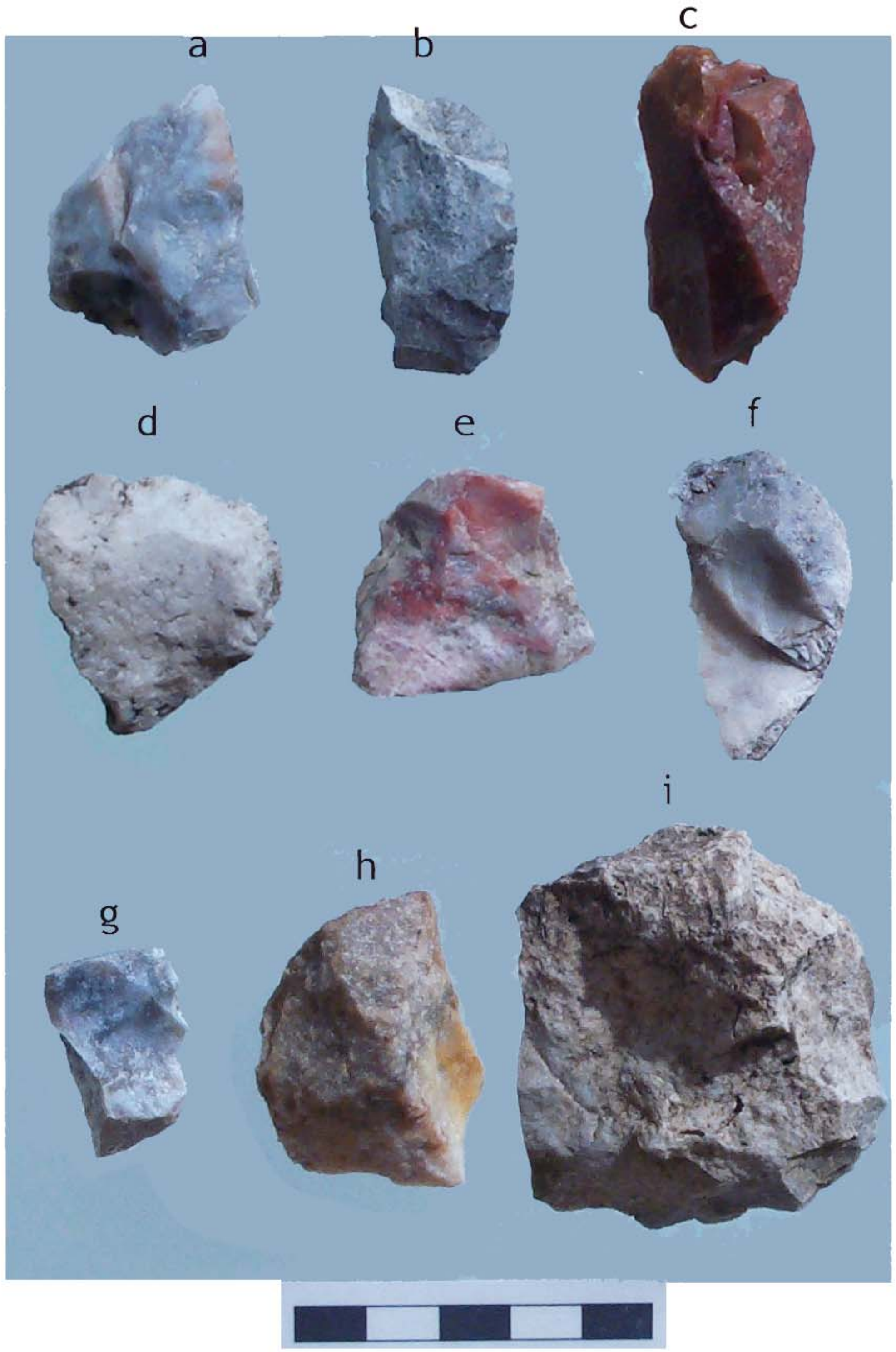
a - Bipolar #1305 b - Bipolar #7132 c - Bifacial #6009
d - Bifacial #7566 e - Core Frag #6018

Figure A.20.3. Middle occupation cores.



a - # 367 b - # 940 c - # 2458 d - # 3520
e - # 3532 f - # 3533 g - # 3531 h - # 4804
i - # 4779 j - # 5931 k - # 6716 l - # 7829
m - # 8086 n - # 9914 o - # 9933 p - # 10540 q - # 10648

Figure A.20.4. Lower occupation amorphous cores.



0 cm. 5

a - #4983 b - #5579 c - #5608
d - #10050 e - #10649 f - #7195
g - #7975 h - #10497 i - #10541

Figure A.20.5. Lower occupation bifacial cores.

0 cm. 5

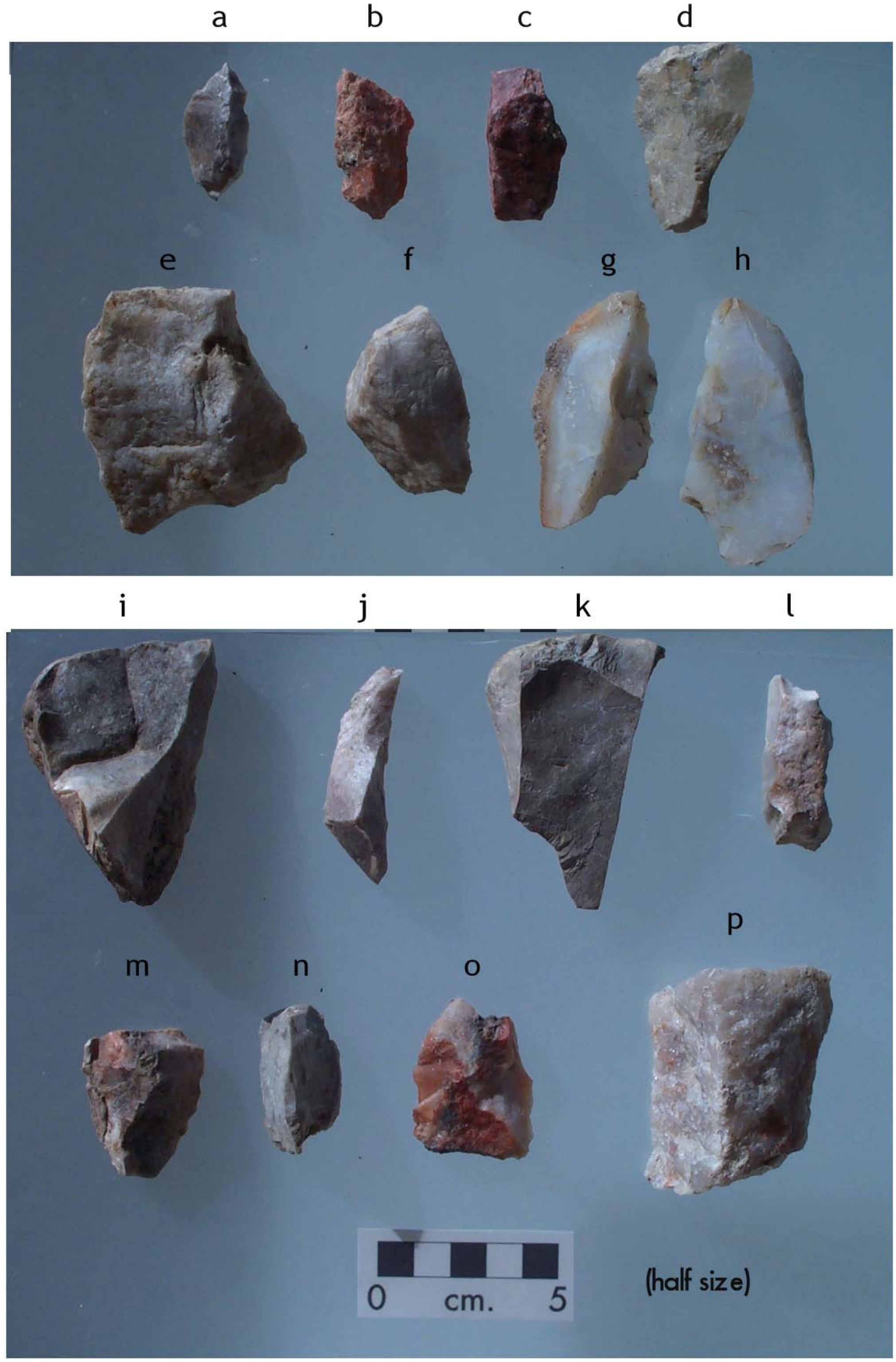
a - #1669 b - #2398 c - #2614 d - #2632
e - #2739 f - #3790 g - #3949 h - #4176

Figure A.20.6. Lower occupation bifacial cores.

0 cm. 5

a - # 4146 b - # 4178 c - # 4802 d - # 4953
e - # 4955 f - # 6309 g - # 6625 h - # 7987

Figure A.20.7. Lower occupation bifacial cores.

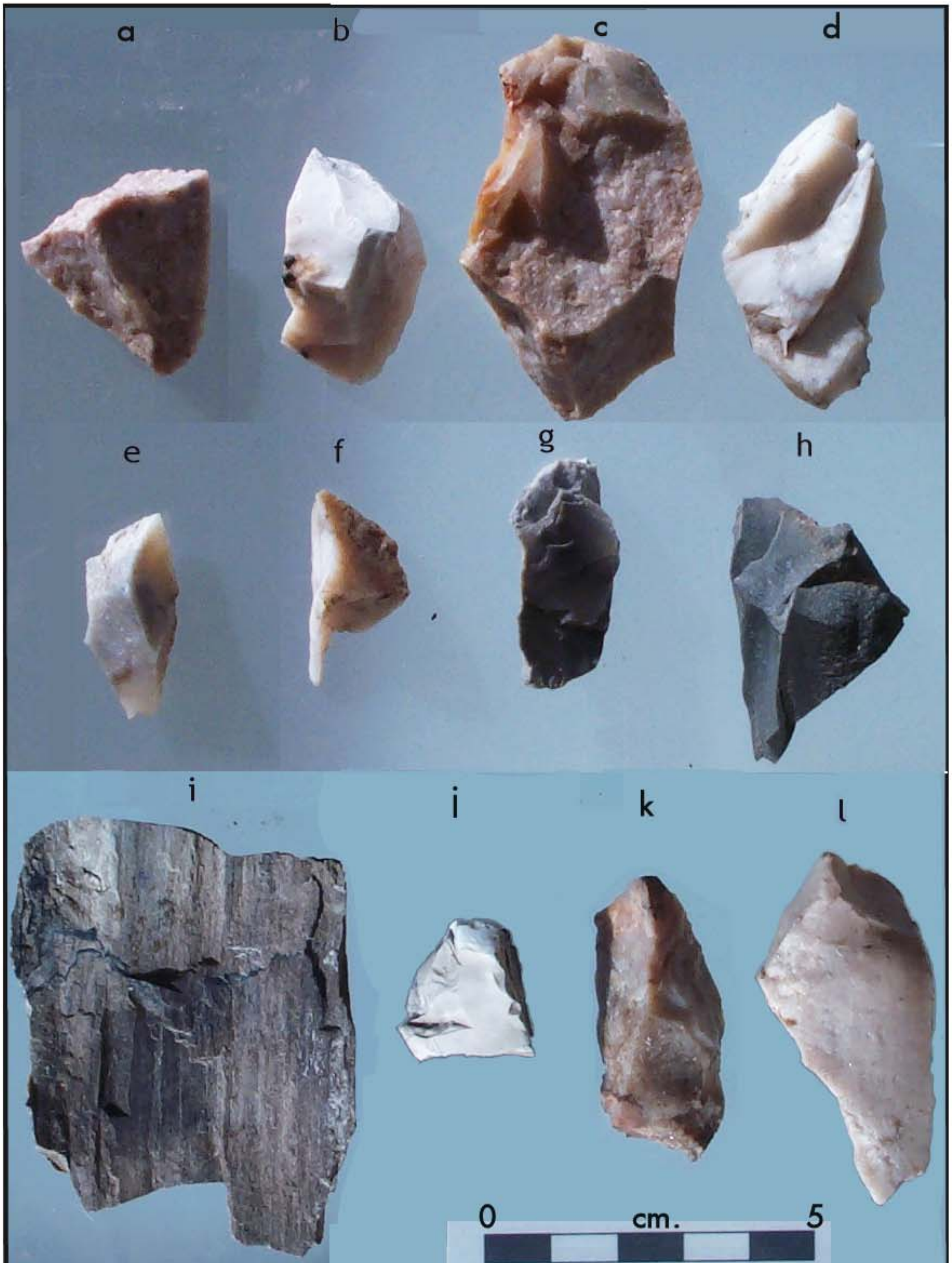


a - # 8920	b - # 9287	c - # 9915	d - # 9918
e - # 10217	f - # 10654	g - # 10658	h - # 10662
i - # 211	j - # 1667	k - # 2007	l - # 2064
m - # 4319	n - # 5011	o - # 5824	p - # 7461

Figure A.20.8. Lower occupation bipolar cores.

a - # 10662 b - # 10658

Figure A.20.9. Lower occupation refit bipolar core.



a - #942 b - #1195 c - #1218 d - #1972
e - #2286 f - #3469 g - #4783 h - #5020
i - #5671 j - #5826 k - #8054 l - #9926

Figure A.20.10. Lower occupation indeterminate core fragments.

a - flake core - #1668 b - flake core - #7505 c - flake core - #8457 d - platform core - #9938

e - tested cobble - #3055 f - tested cobble - 10247

Figure A.20.11. Lower occupation miscellaneous cores.

Appendix 21. Platform Preparation of Cores.

Table A.21.1. Platform preparation and thermal alteration of cores.

Upper Occupation		Levels 0 to 2	Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grinding	Edge Crushing	Edge Flaking	Surface Grinding	Surface Crushing	Surface Flaking	Yes	Maybe	No	N/A
All	16	10	6	2	1	4	1	10	12	0	2	2
Amorphous	5	2	1	0	0	0	0	2	4	0	1	0
Bifacial	7	6	4	1	1	4	0	6	6	0	0	1
Bipolar	2	1	1	1	0	0	1	1	1	0	0	1

Level 3		Level 3	Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grinding	Edge Crushing	Edge Flaking	Surface Grinding	Surface Crushing	Surface Flaking	Total	Maybe	No	N/A
All	2	2	1	0	0	2	0	2	2	0	0	0
Bifacial	2	2	1	0	0	2	0	2	2	0	0	0

Middle Occupation		Levels 4 to 6	Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grinding	Edge Crushing	Edge Flaking	Surface Grinding	Surface Crushing	Surface Flaking	Total	Maybe	No	N/A
All	5	4	3	1	0	3	1	3	3	0	0	2
Bifacial	2	2	2	0	0	2	0	2	1	0	0	1
Bipolar	2	2	1	1	0	1	1	1	1	0	0	1
Indeterminate	1	0	0	0	0	0	0	0	1	0	0	0

Level 7		Level 7	Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grinding	Edge Crushing	Edge Flaking	Surface Grinding	Surface Crushing	Surface Flaking	Total	Maybe	No	N/A
All	6	3	2	0	2	2	0	2	6	0	0	0
Bifacial	1	1	1	0	1	1	0	1	1	0	0	0
Bipolar	1	0	0	0	0	0	0	0	1	0	0	0
Indeterminate	3	2	1	0	1	1	0	1	3	0	0	0

Lower Occupation		Levels 8 to 12	Preparations						Thermal Alteration			
	Total	Prepared Platforms	Edge Grinding	Edge Crushing	Edge Flaking	Surface Grinding	Surface Crushing	Surface Flaking	Total	Maybe	No	N/A
All	89	62	47	2	21	31	9	39	69	2	8	6
Amorphous	19	13	10	0	1	6	2	7	14	1	4	0
Bifacial	33	30	27	0	15	16	0	19	30	0	1	2
Bipolar	17	14	7	2	1	7	6	10	13	1	1	2
Indeterminate	11	4	3	0	4	2	0	3	8	0	1	2

Appendix 22. Descriptive Statistics of Cores

Table A.22.1. Descriptive statistics of cores.

Upper	All types					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	17	36.4	147	33.8	72.3	mm
Width	17	23.5	113	24.8	51.6	mm
Thickness	17	12	96	24.6	34.3	mm
Weight	17	10.4	734	237.2	178.6	g

Upper	Amorphous					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	5	80.5	147	31.3	112.5	mm
Width	5	55.7	113	24.7	81.2	mm
Thickness	5	36.2	96	23.1	65.2	mm
Weight	5	172	734	235.9	480.0	g

Upper	Bifacial					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	7	36.4	85.7	15.9	56.2	mm
Width	7	24.6	54.9	9.9	39.9	mm
Thickness	7	12	25.4	5.0	19.9	mm
Weight	7	10.6	104	31.8	43.5	g

Upper	Bipolar					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	2	69	80.4	8.1	74.7	mm
Width	2	46.4	54.8	5.9	50.6	mm
Thickness	2	30.3	42.7	8.8	36.5	mm
Weight	2	76.8	204	90.2	140.6	g

Upper	Flake-core					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	1	40.3	40.3	0.0	40.3	mm
Width	1	35.5	35.5	0.0	35.5	mm
Thickness	1	15.6	15.6	0.0	15.6	mm
Weight	1	23.2	23.2	0.0	23.2	g

Upper	Indet.					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	1	41.8	41.8	0.0	41.8	mm
Width	1	31.3	31.3	0.0	31.3	mm
Thickness	1	16.1	16.1	0.0	16.1	mm
Weight	1	17	17	0.0	17.0	g

Middle	All core types					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	5	32.5	43.8	4.1	37.6	mm
Width	5	19.6	31.2	4.9	27.7	mm
Thickness	5	11.8	19.5	3.2	14.6	mm
Weight	5	9.4	21.6	5.1	12.7	g

Middle	Bipolar cores					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	2	37.9	43.8	4.2	40.9	mm
Width	2	19.6	26.6	4.9	23.1	mm
Thickness	2	13	19.5	4.6	16.3	mm
Weight	2	9.4	21.6	8.6	15.5	g

Middle	Bifacial cores					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	2	35.8	37.9	1.5	36.9	mm
Width	2	30.5	30.5	0.0	30.5	mm
Thickness	2	11.8	12.6	0.6	12.2	mm
Weight	2	9.6	11.2	1.1	10.4	g

Middle	Indet.					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	1	32.5	32.5	0.0	32.5	mm
Width	1	31.2	31.2	0.0	31.2	mm
Thickness	1	16.3	16.3	0.0	16.3	mm
Weight	1	11.5	11.5	0.0	11.5	g

Lower	All core types					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	85	22.8	94.6	15.8	48.1	mm
Width	85	13.8	71.2	13.7	33.2	mm
Thickness	85	7.3	45	8.9	20.3	mm
Weight	85	3.2	297	52.9	42.5	g

Lower	Amorphous					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	19	35.7	94.6	15.4	54.6	mm
Width	19	22.6	71.2	11.3	42.4	mm
Thickness	19	17.5	45	6.9	27.9	mm
Weight	19	13.4	187	48.1	63.4	g

Lower	Bifacial					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	33	22.8	93.5	16.1	42.9	mm
Width	33	13.8	70.7	13.9	29.5	mm
Thickness	33	7.3	43.1	7.1	15.8	mm
Weight	33	3.3	297	55.3	30.5	g

Lower	Bipolar					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	17	37.3	74.6	13.9	55.0	mm
Width	17	17.3	54.3	11.8	32.7	mm
Thickness	17	11.3	35.3	7.7	21.1	mm
Weight	17	6	138	40.4	45.2	g

Lower	Flake cores					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	2	33.3	40.4	5.0	36.9	mm
Width	2	22.3	26	2.6	24.2	mm
Thickness	2	9.8	16.8	4.9	13.3	mm
Weight	2	6.5	9.5	2.1	8.0	g

Lower	Indet .type					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	11	27.4	57	10.8	40.6	mm
Width	11	15.4	50.1	9.6	26.3	mm
Thickness	11	12	22.1	3.1	15.9	mm
Weight	11	3.2	64.6	18.6	19.2	g

Lower	Tested cobbles					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	2	60.5	73.5	9.2	67.0	mm
Width	2	51.7	64.3	8.9	58.0	mm
Thickness	2	40	44.8	3.4	42.4	mm
Weight	2	126	238	79.2	181.7	g

Lower	Platform core					
	Freq.	Min	Max	St. Dev.	Mean	Measure
Length	1	45.6	45.6	0.0	45.6	mm
Width	1	30.7	30.7	0.0	30.7	mm
Thickness	1	28.5	28.5	0.0	28.5	mm
Weight	1	41.1	41.1	0.0	41.1	g

Appendix 23. Contour Density Maps.

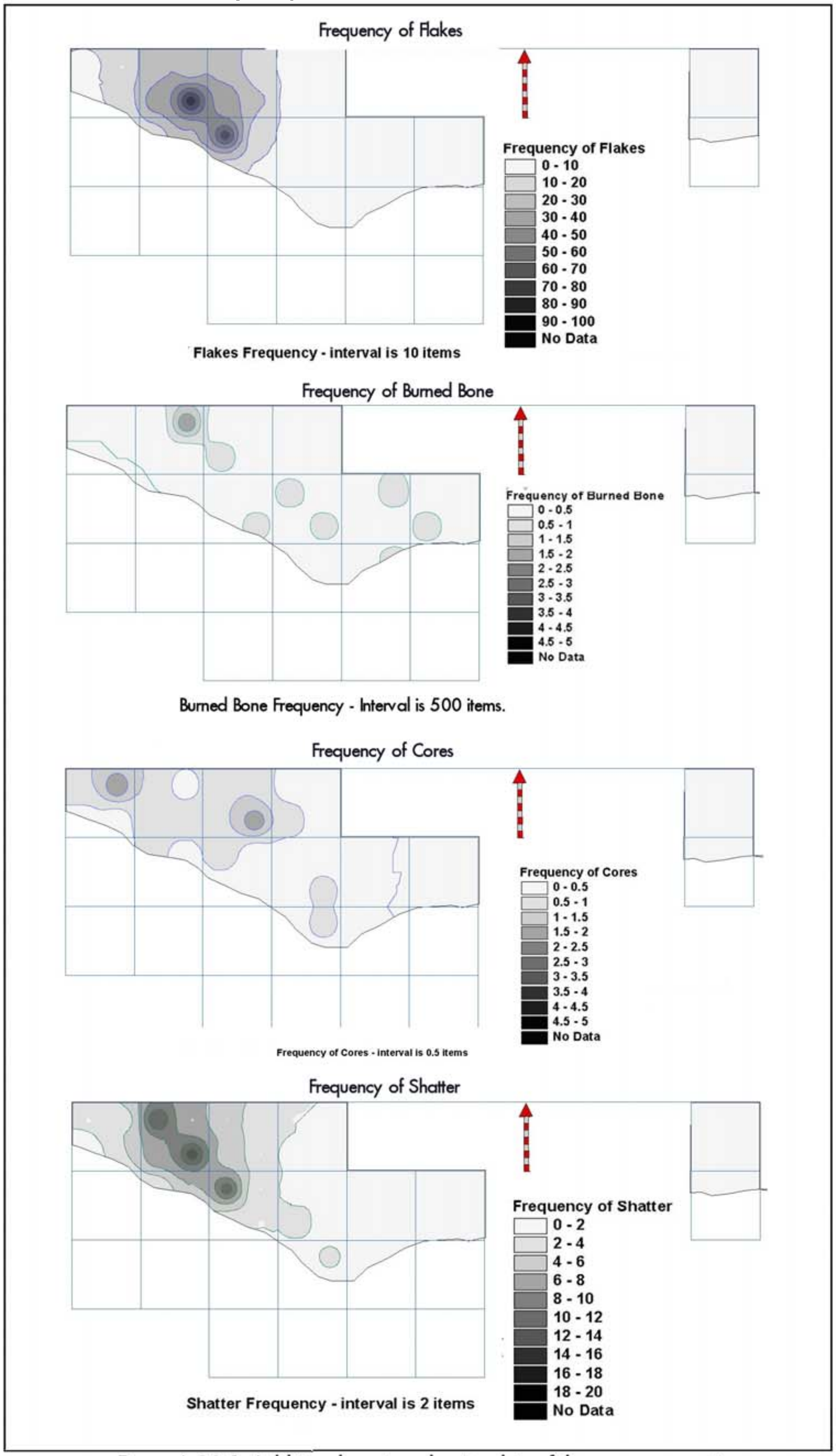


Figure A.23.1. Additional contour density plots of the upper occupation.

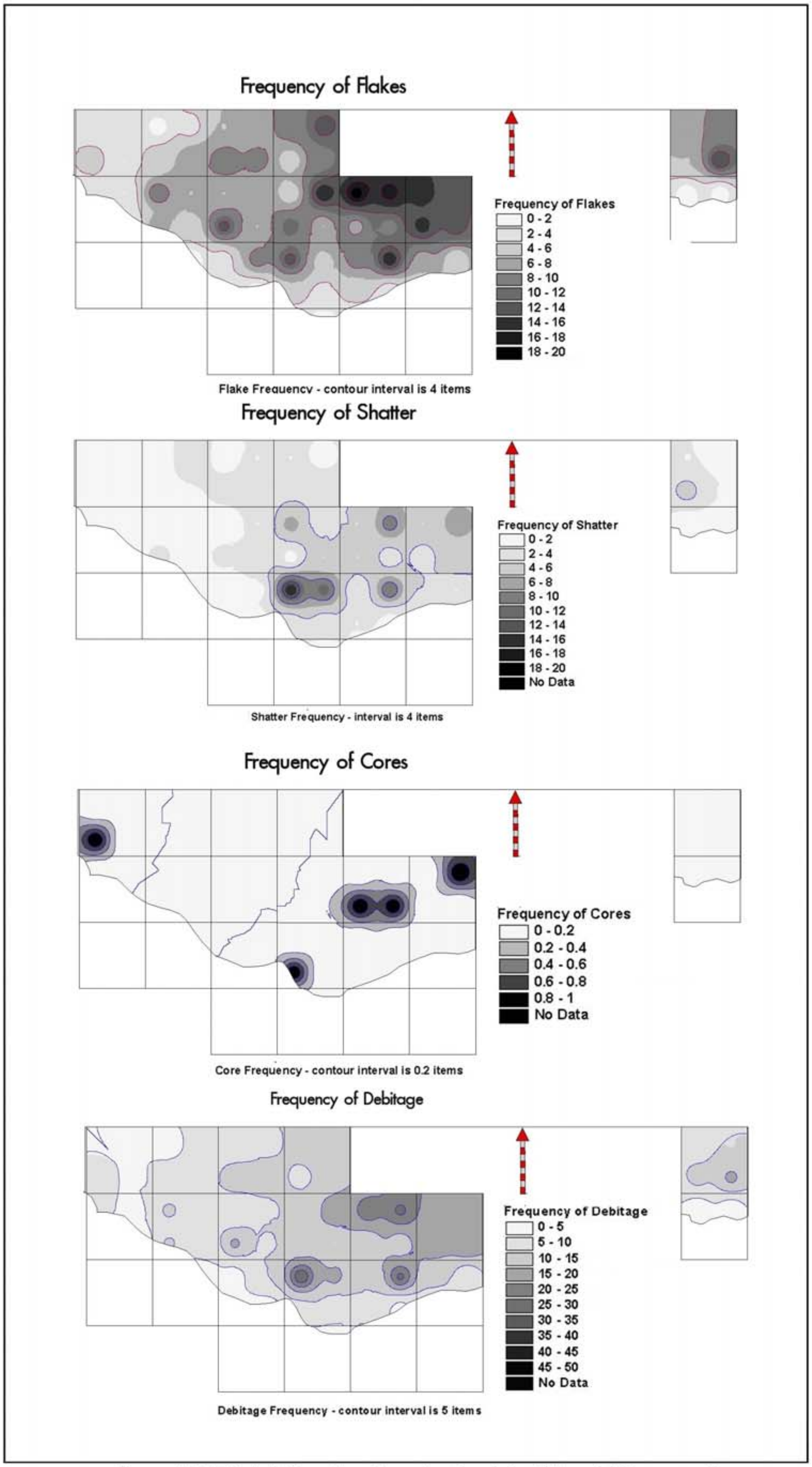


Figure A.23.2. Additional contour density plots of the middle occupation.

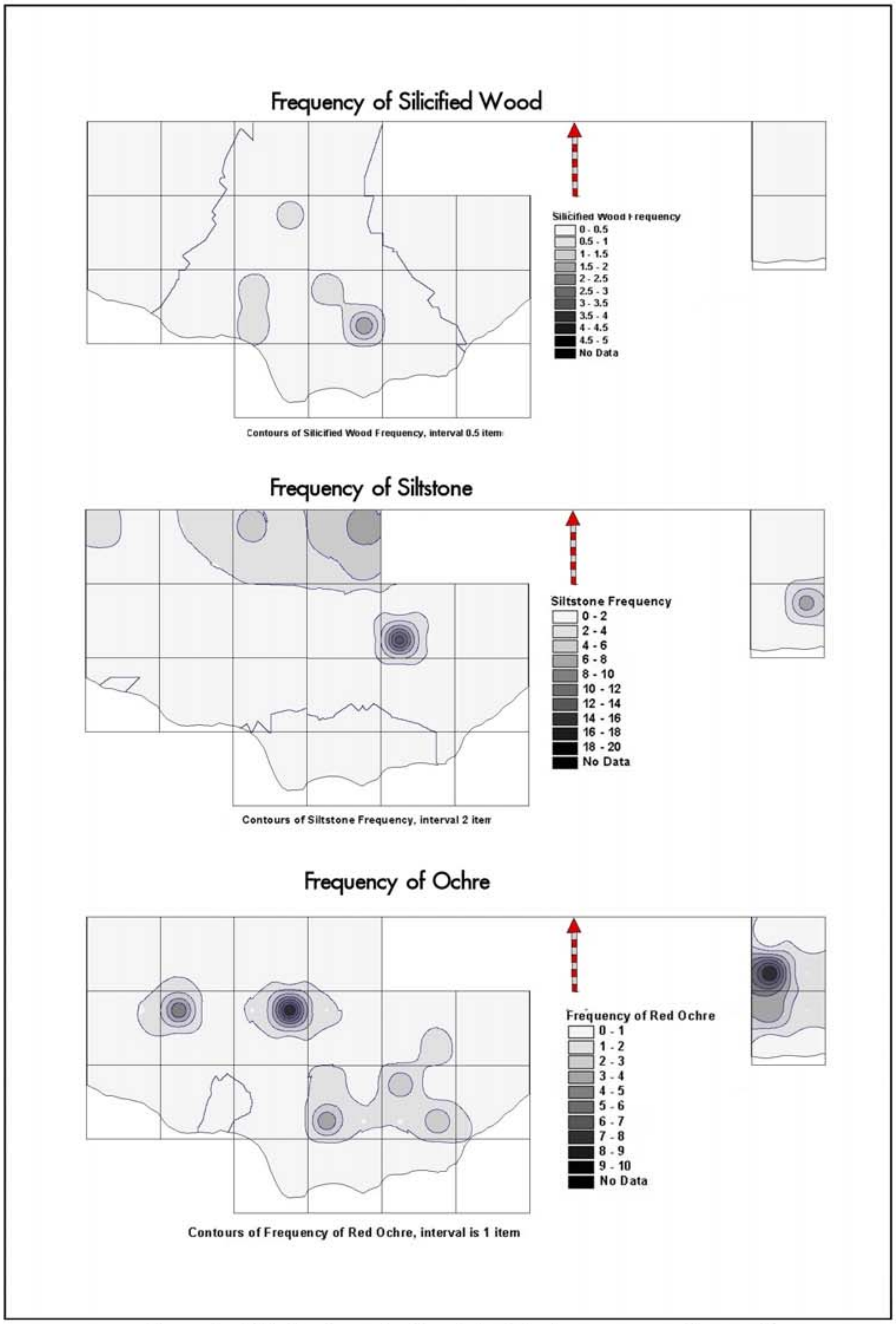


Figure A.23.3. Contour density plots of the lower occupation, part one.

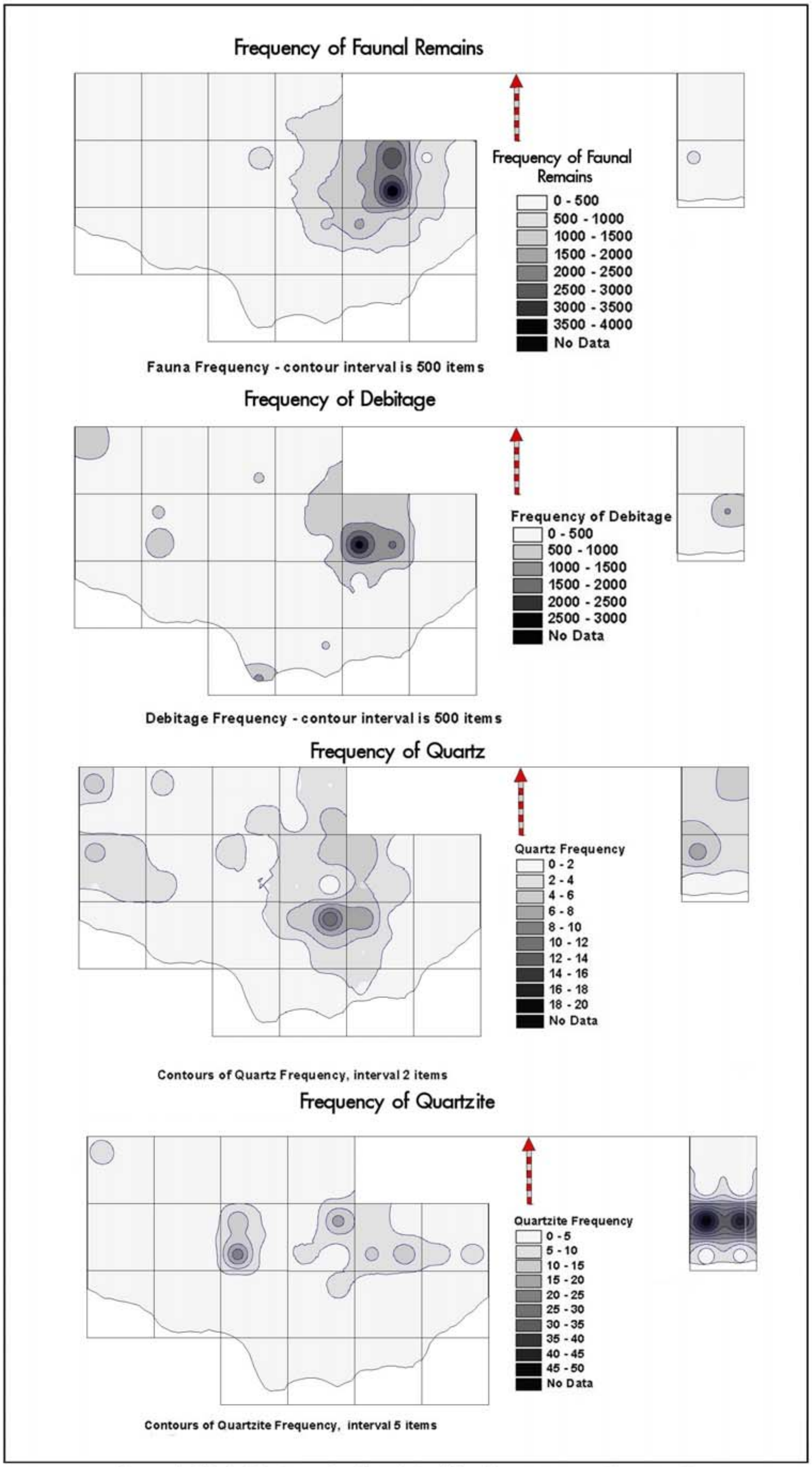


Figure A.23.4. Contour density plots of the lower occupation, part two.

Appendix 24. Pearson's Product Method Equation.
From Alvi (1995:143-147).

"Covariance of X and Yr = $1/N\sum(\overline{X}-X)(\overline{Y}-Y)$

$\overline{X}$=mean of X'

$\overline{Y}$=mean of Y

Covariance of X and Y = $!/N\sum XY-(\overline{X}\cdot\overline{Y})$

Covarriance of X and Y = $1/N(\sum X\cdot\sum Y) - (\overline{X} \cdot \overline{Y})$

$q_X=\sqrt{}([\sum(X-\overline{X})^2]/N)$

$q_Y=\sqrt{}([\sum(Y-\overline{Y})^2]/N)$

Z-score X = $(X_i - X)/q_X$

$R=\sum XY/q_Xq_Y$

$R= [(1/N)\sum XY - X\cdot Y]/\sqrt{}(\sum[X^2/N]-X^2)(\sum[Y^2/N]-Y^2)$"

Alvi (1995: 143-147)

Appendix 25: Spearman's Rank Order Correlation Coefficient Equation.

A rank order is just a sort from the largest (1) value to the smallest (N) of a series of cell values. It operates on an Ordinal scale, meaning 1, 2, 3, 4, 5, and so forth. The eduation I used was from Alvi (1995:150-151)

"$R_s=1-[6\sum d^2/N(N^2-1)]$

R_s is the Spearman's rank order correlation coefficient.

d is the rank difference between 2 variables (X_i and Y_i),

N is the number of items in the data " (Alvi 1995:150-151).

Appendix 26. The Moran I and Geary C Equations.

A.26.1 The Moran I Statistic.

The equation I used was from Gladfelter and Tiedemann (1985:498-499).

$$I = [N \sum_{I=1}^{N} \sum_{J>1}^{N} (xi-\bar{X})(xj-\bar{X})/J\sum_{I=1}^{N}(xi-X)^2$$

$$q_n{}^2=\{(N^2J+3J^2-N\sum_{I=1}^{N}L^2)+/[J^2(N^2-1)]\} - E_i^2$$

$$q_r{}^2=(\{N[J(N^2+3-3N)+3J^2-N\sum_{I=1}^{N}L^2] - K[J(N^2-N)+6J^2 \; - \; (2N\sum_{I=1}^{N}L^2/[J^2(N-1)(N-2)(N-3)]]) \} - E_i^2)$$

E_i= -1/(N-1)

Z_i=(I-E_i)/q_n (for normally distributed data)

Z_i=(I-E_i)/q_r (for randomly distributed data)

I = Moran's spatial autocorrelation co-effienct

Z_i= I standardized to approximate a normal (0,1) deviate.

E_i= expectation of I under the assumption of random placement.

q_n or q_r = standard deviations of estimates of E_i

N= number of cells in the study region

J= number of joins between adjacent pairs of cells

K= kurtosis of the observations.

$\sum_{I=1}^{N} \sum_{J>1}^{N} (xi-\bar{X})(xj-\bar{X})$ = cross products of deviations from the mean summed over all cells *i* summed over all cells j, j contiguous to i, and j>i (that is no double counting)

$\sum_{I=1}^{N} L^2$ = squared number of joins per cell, summed over all cells. "

(Gladfelter and Tiedmann 1985:498-499).

A.26.2 The Geary C Statistic

The Equation I used was from Gladfelter and Tiedemann 1985:498-499.

$$"C= [(N-1)/2(2J)][\sum_{I=1}^{N}\sum_{J=1}^{N} (xi\ xj)^2/\sum_{I=1}^{N} (xi - \bar{X})^2$$

$$q_n{}^2=(\{n2(2J/N)2 + 2N[(2J/N) + (\sum_{I=1}^{N} L^2/N)]\} .\ (N-1)/[N^2(n+1)(2J/N)^2]) - E_c{}^2$$

$$qr^2 =[\sum_{I=1}^{N} L^2\{[N(N^2-N+2)K] -\{n(N^2+3N-6)(q_x{}^2)^2]\} +2J(2J+2)\{\{N(N^2-3N+3)(q_x{}^2)2]-[N(N-1)K\}\}).$$

$$\{1/[(N-1)(N-2)(N-3)]\}\{(N-1)^2/[N^2(2J)^2(q^2)2]\}] - E_c{}^2$$

Ec=1.0

$Z_c=(E_c-C)/\ q_n$ (for normally distributed data)

Zc= $(E_i-C)/q_r$ (for randomly distrubuted data)

C=Geary's spatial autocorrellation coefficient.

Z_i= C standardized to approximate a normal (0,1) deviate.

E_i= expectation for C under the assumption of random placement

,q_n and q_r = standard deviates from the estimates of Ec.

N= number of cells in the study region.

J= number of joins between adjacent pairs of cells.

$Q_x{}^2$= variance of the observations.

K= kurtosis of the observations.

$\sum_{I=1}^{N}\sum_{J=1}^{N} (xi\ xj)^2$ = squares of the differences summed over all cells i, for each cell i summed over all cells j, j contiguous to i.

$\sum_{I=1}^{N} L^2$ = squared number of joins per cell, summed over all cells."

(Gladfelter and Tiedemann 1985:498-499).

Appendix 27. Moran I and Geary C Statistic Output of the Lower Occupation.

Table A.27.1. Moran I by frequency.

Frequency	Moran's I	Var. Norm	Var. Rand	Z. Norm	Z.Rand
FCR	-1.225	0.975	0.968	-1.227	-1.231
Debitage	0.665	0.975	0.730	0.687	0.794
Flakes	0.629	0.975	0.713	0.651	0.761
Shatter	1.013	0.975	0.962	1.040	1.046
Fauna	0.309	0.975	0.751	0.326	0.371
Burned Bone	0.263	0.975	0.726	0.280	0.324
Cores	0.892	0.975	0.961	0.917	0.924
Total items	0.547	0.975	0.797	0.568	0.628
Ochre	Null	0.975	Null	Null	Null
Siltstone	0.251	0.975	0.841	0.268	0.289
Gronlid	0.150	0.975	0.547	0.116	0.221
Red Willow	0.037	0.975	0.611	0.051	0.064
Quartz	Null	0.975	Null	Null	Null
Silicified Wood	0.062	0.975	0.718	0.076	0.089
Quartzite	0.116	0.975	0.740	0.182	0.209
Medial Portions	0.929	0.975	0.967	0.954	0.958
Proximal Portions	1.143	0.975	0.925	1.171	1.117
Distal Portions	Null	0.975	Null	Null	Null
All Broken Flakes	0.407	0.975	0.650	0.426	0.521
Split Flakes	0.493	0.975	0.951	0.513	0.519
Primary Decort	0.063	0.975	0.474	0.077	0.110
Secondary Decort	0.453	0.975	0.883	0.472	0.496
Tertiary Decort	-1.233	0.975	0.958	-1.236	-1.246
All Decort	-0.639	0.975	0.961	-0.634	-0.639
Bipolar	0.178	0.975	0.882	0.194	0.204
Shaping	-1.241	0.975	0.943	-1.244	-1.265
Bi-Redu	0.539	0.975	0.938	0.559	0.570
Hard Hammer	0.473	0.975	0.960	0.492	0.496
Soft Hammer	0.576	0.975	0.985	0.597	0.593
Heated SRC	1.125	0.975	0.932	1.153	1.179

Table A.27.2. Geary C by frequency.

Frequency	Geary's C	Var. Norm	Var. Rand	Z. Norm	Z.Rand
FCR	2.459	1.923	2.168	-1.052	-0.991
Debitage	0.016	1.923	11.084	0.709	0.295
Flakes	0.012	1.923	11.717	0.712	0.289
Shatter	0.255	1.923	2.376	0.537	0.483
Fauna	0.000	1.923	10.316	0.721	0.311
Burned Bone	0.000	1.923	11.228	0.721	0.298
Cores	0.000	1.923	2.431	0.721	0.641
Total items	0.004	1.923	8.593	0.718	0.340
Ochre	Null	1.923	Null	Null	Null
Siltstone	0.000	1.923	6.937	0.721	0.380
Gronlid	0.017	1.923	17.948	0.709	0.232
Red Willow	0.050	1.923	15.542	0.685	0.241
Quartz	Null	1.923	Null	Null	Null
Silicified Wood	0.000	1.923	11.560	0.721	0.294
Quartzite	0.000	1.923	10.711	0.721	0.306
Medial Portions	0.000	1.923	2.191	0.721	0.676
Proximal Portions	0.112	1.923	2.265	0.64	0.59
Distal Portions	Null	1.923	Null	Null	Null
All Broken Flakes	0.075	1.923	14.086	0.667	0.246
Split Flakes	0.641	1.923	2.796	0.259	0.214
Primary Decort	0.000	1.923	20.680	0.721	0.220
Secondary Decort	0.000	1.923	5.338	0.721	0.433
Tertiary Decort	3.217	1.923	2.547	-1.599	-1.389
All Decort	1.276	1.923	2.424	-0.199	-0.177
Bipolar	0.000	1.923	5.380	0.721	0.431
Shaping	2.490	1.923	3.106	-1.075	-0.846
Bi-Redu	0.107	1.923	3.295	0.644	0.492
Hard Hammer	0.468	1.923	2.478	0.384	0.338
Soft Hammer	0.298	1.923	1.539	0.506	0.566
Heated SRC	0.014	1.923	3.515	0.771	0.526

Table A.27.3. Moran I by weight.

Weight	Moran's I	Var. Norm	Var. Rand	Z. Norm	Z.Rand
FCR	0.110	0.975	0.868	0.124	0.132
Debitage	0.232	0.975	0.261	0.249	0.481
Flakes	0.183	0.975	0.208	0.199	0.430
Shatter	0.386	0.975	0.947	0.405	0.410
Fauna	0.412	0.975	0.841	0.431	0.464
Burned Bone	0.263	0.975	0.726	0.280	0.324
Cores	0.500	0.975	0.936	0.516	0.530
Total items	0.547	0.975	0.797	0.598	0.628
Ochre	Null	0.975	Null	Null	Null
Siltstone	0.251	0.975	0.841	0.268	0.289
Gronlid	0.345	0.975	0.920	0.363	0.373
Red Willow	0.037	0.975	0.611	0.051	0.064
Quartz	Null	0.975	Null	Null	Null
Silicified Wood	0.033	0.975	0.406	0.047	0.072
Quartzite	0.166	0.975	0.740	0.182	0.209
Medial Portions	0.747	0.975	0.972	0.770	0.771
Proximal Portions	0.252	0.975	0.623	0.268	0.335
Distal Portions	Null	0.975	Null	Null	Null
All Broken Flakes	0.542	0.975	0.699	0.563	0.665
Split Flakes	0.510	0.975	0.906	0.530	0.550
Primary Decort	0.063	0.975	0.474	0.077	0.110
Secondary Decort	0.453	0.975	0.883	0.472	0.496
Tertiary Decort	-0.323	0.975	0.822	-0.314	-0.342
All Decort	-0.639	0.975	0.961	-0.634	-0.639
Bipolar	0.122	0.975	0.820	0.137	0.149
Shaping	-0.965	0.975	0.926	-0.964	-0.989
Bi-Redu	0.315	0.975	0.920	0.333	0.342
Hard Hammer	0.473	0.975	0.96	0.492	0.496
Soft Hammer	0.089	0.975	0.970	0.104	0.104
Heated SRC	1.125	0.975	0.932	1.153	1.179

Table A.27.4. Geary C by weight.

Weight	Geary's C	Var. Norm	Var. Rand	Z. Norm	Z.Rand
FCR	0.022	1.923	5.931	0.705	0.402
Debitage	0.029	1.923	28.702	0.700	0.181
Flakes	0.009	1.923	30.688	0.714	0.179
Shatter	0.438	1.923	2.946	0.405	0.328
Fauna	0.000	1.923	6.949	0.721	0.379
Burned Bone	0.000	1.923	11.228	0.721	0.298
Cores	0.000	1.923	3.354	0.721	0.546
Total items	0.004	1.923	8.593	0.718	0.340
Ochre	Null	1.923	Null	Null	Null
Siltstone	0.000	1.923	6.937	0.721	0.380
Gronlid	0.000	1.923	3.958	0.721	0.503
Red Willow	0.050	1.923	15.542	0.685	0.241
Quartz	Null	1.923	Null	Null	Null
Silicified Wood	0.000	1.923	23.230	0.721	0.207
Quartzite	0.000	1.923	10.711	0.721	0.306
Medial Portions	0.000	1.923	2.025	0.721	0.703
Proximal Portions	0.074	1.923	15.112	0.668	0.238
Distal Portions	Null	1.923	Null	Null	Null
All Broken Flakes	0.073	1.923	12.267	0.668	0.265
Split Flakes	0.110	1.923	4.500	0.642	0.419
Primary Decort	0.000	1.923	1.923	0.721	0.220
Sec. Decort	0.000	1.923	5.338	0.721	0.433
Tertiary Decort	0.715	1.923	7.637	0.206	0.103
All Decort	1.276	1.923	2.424	-0.199	-0.177
Bipolar	0.000	1.923	7.724	0.721	0.360
Shaping	1.919	1.923	3.745	-0.663	-0.475
Bi-Redu	0.131	1.923	3.963	0.627	0.436
Hard Hammer	0.468	1.923	2.478	0.384	0.338
Soft Hammer	0.595	1.923	2.090	0.292	0.280
Heated SRC	0.014	1.923	3.515	0.711	0.526